COLLEGE OF EN

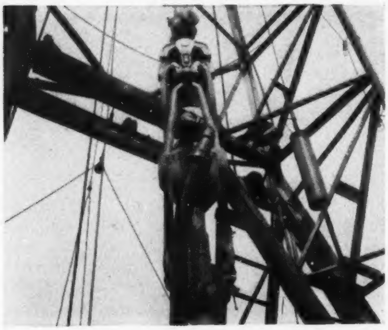
The Cornell

MARCH, 1952

VOL. 17, NO. 6

25 CENTS

Another page for **YOUR BEARING NOTEBOOK**



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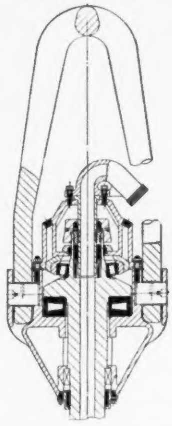

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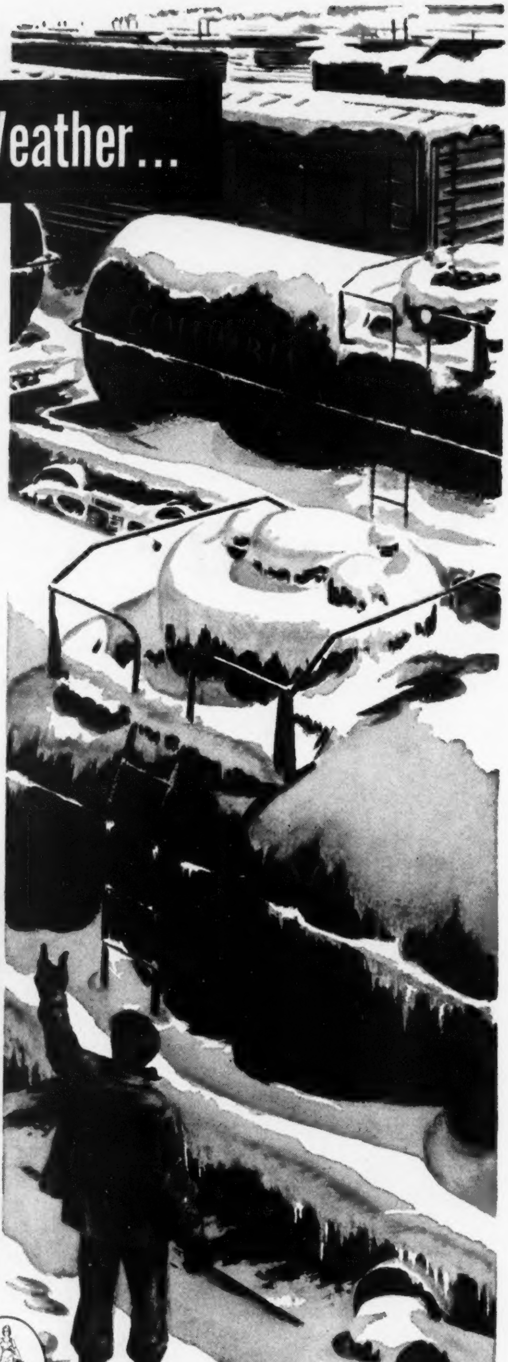

COLUMBIA-SOUTHERN CAUSTIC CARS HELP INSURE EASY UNLOADING WITHOUT STEAMING!

During the transporation delays of the 1951 winter, a car of liquid caustic soda was shipped January 25 from Columbia-Southern's Natrium, West Virginia, plant . . . arrived Chicago January 30 . . . spotted February 9 . . . unloaded February 12 *without the use of steam, and with a full line within a minute.*

During this nineteen day period the car was in transit, outside temperatures were mostly below freezing, twice reaching as low as 15 degrees below zero! Yet easy unloading was assured by the efficiency of the Columbia-Southern designed car.

The Columbia-Southern caustic tank car is one of the many valuable contributions to industry made by Columbia-Southern, pioneer in better transportation and handling of liquid caustic soda.

Columbia-Southern's policy is not only to make the highest grade caustic soda, but to ship it with caution and care.

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· the patented tank car lining which permits delivery of liquid caustic soda without metallic pick-up—in any concentration · the fusion welding which eliminates rivets as a possible source of leaks · increased tank car insulation · greatly improved heating equipment · and numerous other unloading and safety improvements.

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THE DU PONT DIGEST

Operator and foreman *check raw materials on a production control board which records every operation in a Du Pont plant.*

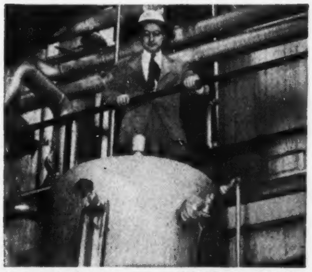
Ch. E's at Du Pont

[THIRD OF A SERIES]

Work as production supervisors prepares chemical engineers for jobs in management

The last issue of the *Digest* described the broad opportunities offered chemical engineers in research and development at Du Pont. Now let's look at the opportunities in production supervision.

In this important phase of plant operation, Ch. E.'s and others are responsible for investment in plant facilities, supply of raw materials, supervision of operation and maintenance, cost and shipment of finished products, as well as personnel relations, training and safety.



George B. Bradshaw, Jr., *B.S.Ch.E., M.I.T. '40, assistant superintendent, inspects a unit used in ammonia synthesis operation.*

Normally, chemical engineers enter production supervision by reason of preference and special abilities. Their first step depends on which of ten operating departments they work in. For example, in one department they follow a training program as student operators. In another, training in a plant laboratory familiarizes the engineers with processes and products.

After the training period, the men are given supervisory responsibilities, usually starting as foreman. At this level they meet problems like these:

1. Occasionally, in a still connected to a sulfonator by a pipe line with a single valve, the product disappeared, and residue increased. The supervisor's study of control data showed that small amounts of gaseous sulfur trioxide were venting into the still causing decomposition of the product. His recommended installation of a positive pressure block in the pipe line eliminated the difficulty.

2. A high temperature batch reaction process was revised to increase production of a critical material. For safety, adjacent reactors had to be shut down as work on each unit proceeded. The supervisor planned maintenance and batch schedules to minimize costly down-time and re-trained personnel for the new process.

In solving such problems, supervisors have an opportunity to use all their knowledge and ingenuity. Equally important, they acquire the background and varied experience that prepare them for advancement to responsible positions in management and administration.

Inspecting nylon *filaments during manufacture. They are made by extruding molten polymer through spinnerets under pressure.*

NEXT MONTH—The fourth article in this series will deal with process development—to many engineers the most interesting part of plant operation.

Conrad R. Graeber, Jr., *B.S.Ch.E., Lehigh '51, control supervisor, examines flow sheets for the manufacture of methacrylates.*

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THE CORNELL engineer

MARCH, 1952 VOLUME 17 NUMBER 6

COVER—Cornell's Hydroelectric Plant as viewed from the Suspension Bridge.

—*Stuckelman*

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Colloidal Graphite In Industry

By HOWARD A. ACHESON, M.E. '23

Graphite has long been recognized as a unique mineral having broad usefulness because of its lubricity and its ability to conduct electricity. These properties, coupled with its resistance to chemical attack, have made it an important article of commerce. Natural graphite, however, carries rather high percentages of siliceous impurities and is available only in the form of flakes and powders. Skillful refining methods have been developed which reduce greatly the foreign matter in the mined product, and the molding of natural graphite into rigid forms through the use of binders has extended its adaptability somewhat.

Advent of Manufactured Graphite

Science, however, through the genius of Edward Goodrich Acheson, produced in 1896 a pure manufactured graphite. Employing huge electric furnaces powered by the falling waters of Niagara, this pioneer in electrothermal processes turned out graphite in the form of easily machinable rods, slabs, cylinders, etc., as well as unctuous powders. Thus he brought into existance a new electrode material free of binders and lubricating graphite having the purity of the order of 99.9 per cent. He was the first to prepare commercial silicon carbide (best known by the trade-mark under which it was marketed—"Carborundum"), a feat he accomplished in 1891.

When silicon carbide is subjected to a temperature higher than that required for its formation, it decomposes, yielding elemental silicon and graphitic carbon. It was this observation which gave birth to the manufactured graphite industry. (Man-made graphite is sometimes erroneously referred to as synthetic or artificial graphite. It is also electrographite and Acheson graphite.)

The rigid forms of graphite found immediate acceptance in the electrochemical industry and were eventually adopted for the manufacture of steel. Acheson, however, was not satisfied to confine the use of his lubricating graphite to incorporation with greases or to those relatively few applications where lubrication was achieved by the dusting of graphite powder. The crucible field in the late nineteenth century was consuming most of the natural graphite being mined, but unfortunately this use was barred to manufactured graphite because of its great purity. The extraneous matter in mined graphite, in conjunction with clay, played an important part in the binding of crucibles.

Acheson's Investigations

The story of the unfruitful work on crucible fabrication bears mentioning, since the observations made during the period were responsible for the successful colloidalizing of graphite.

The failure of crucibles made of pure graphite to give the required strength was attributed to the poor-quality domestic clays worked with; but certain German clays were highly plastic and gave results somewhat more promising—though still far from satisfactory. Why did clays vary so widely in plasticity? Further investigation revealed that the desirable clays were sedimentary —those carried to their final resting places by streams. The transporting waters were in many cases rich in organic matter leached from the earths drained by the rains.

Aqueous extacts of one of the most common forms of vegetation—straw—were used to treat specimens of poor domestic clays, employing for the purpose a pug mill. An astounding result was achieved. Acheson imparted plasticity to his materials, and aqueous suspensions of clay particles now showed pronounced stability. Subsequent examination of these suspensions with the then-new ultramicroscope indicated that the particles were of colloidal dimensions.

He concluded that the Egyptians used straw in a similar manner to make brick (see the fifth chapter of *Exodus*). His own thoughts on the subject follow:

> The accepted theory of using the straw fibre as a binding agent for the clay had never appealed to me, and it now seemed likely that those ancient people were familiar with the effect I had discovered. I procured some oat straw, boiled it in water, decanted the resultant reddish brown liquid, and mixed it with clay. The result was like that produced with gallo-tannic acid, and equal to the best I had obtained. This explained why the straw was used, and why the Children of Israel were successful in substituting stubble for straw, a course that would hardly be possible were the fibre of the straw depended upon as a bond for the clay, but quite feasible where the extract of the plant was used.

Colloidalization of Graphite

Turning from clay to graphite, he sought to suspend graphite with the aid of straw or similar vegetable extracts. The experimentation necessary to achieve this was considerable, but it terminated in success in 1906. The end result was that a means had been uncovered to produce colloidal graphite in water—and later in oil. During the early efforts, this process was referred to as one of "deflocculation" rather than colloidalization. The initial letters of the words "deflocculated Acheson graphite" give rise to the "dag" trade-mark presently associated with those products comprised of colloidal graphite in oil ("Oildag"), in water ("Aquadag"), in castor oil ("Castordag"), etc.

Surgeon's lamp illuminates recessed spots when wiring new mass spectrometer.
—*Westinghouse*

Properties, Utility of Graphite

Before scanning the industrial uses for colloidal graphite and the films formed with it, it would be well to review the outstanding properties of graphite. This material:

Can withstand temperatures of 3000°C in inert atmospheres

Has a specific gravity between 2.0 and 2.5

Has a hardness of less than 1 on Moh's scale

Possesses a low coefficient of expansion

Is a good conductor of heat and electricity at high temperatures

Has a high black body factor

Is low in photoelectric sensitivity

Is opaque and unctuous

At atmospheric pressure does not combine with oxygen at temperatures below 600°C

Is insoluble in acids and alkalies.

When dispersed in volatile carriers, colloidal graphite may be applied to surfaces by various techniques. Homogeneous films thus deposited are utilized not only for their lubricity and conductivity but also because they can, under conditions, adsorb gas, radiate or absorb heat, and, when necessary, provide opacity.

The suspensions themselves which exhibit Brownian movement, are made up of particles carrying like electrical charges—usually negative in the case of aqueous carriers and positive in organic vehicles.

Fig. 2. Dispersions, applied to chills, patterns, and permanent molds, offer greater efficiency.
—Thomas Paulson and Son

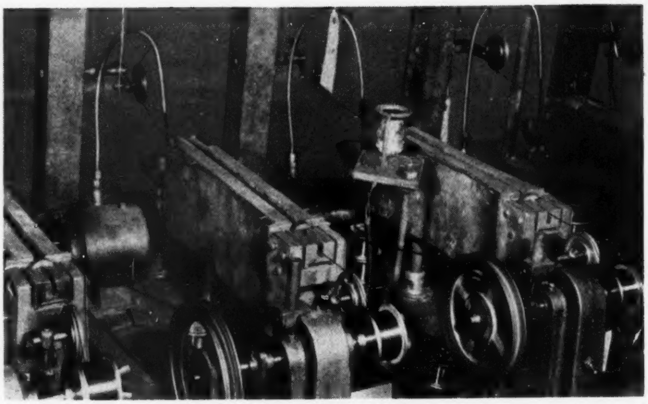


Fig. 1. Tungsten wire passes through a fountain of graphited water and over a battery of burners before reaching the die.
—Thermionic Products

In fact, graphite suspensions possess all of the properties peculiar to lyophobic colloids.

Vital in Wire Drawing

While the development of colloidal graphite was progressing, the General Electric Company was striving to produce ductile tungsten. Colin G. Fink, who was engaged on the project at Schenectady, chanced to sit in on a lecture given by Acheson on the subject of "Deflocculation." Fink, impressed with the possibilities of colloidal graphite in water, obtained a sample for trial as a die lubricant in the drawing of tungsten. The material proved ideal for the purpose. It adhered tenaciously to the wire and was not oxidized by red heat—the condition under which the wire was fabricated. Die wear was reduced to a minimum and wire breakage was practically eliminated. Graphite hydrosol has been used continuously since 1906 for this purpose and is regarded as indispensable in the manufacture of tungsten and molybdenum wires. (See Figure 1.)

High-Temperature Lubricant

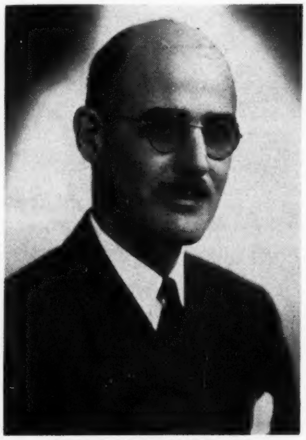
In the wire drawing application just described, films formed with colloidal graphite proved themselves to be effective high tempera-

(*Continued on page* 48)

THE AUTHOR

Howard A. Acheson was born in Buffalo, New York, in 1900, not far from the scene where his eminent father, Edward Goodrich Acheson, carried out pioneer work in electrochemistry. After his preparatory schooling at Culver and in England, the author received his M.E. degree from Cornell in 1923.

Upon graduation he obtained employment with the Armstrong Cork Company, but soon devoted his interest to the manufacture and sale of colloidal graphite products. He married Miriam Felt of Franklin, Pa., and has two children, Howard A. Acheson, Jr., B. Chem.E. '51, also a Cornell graduate, and James C. Acheson, presently enrolled at Culver. Mr. Acheson is President of Acheson Industries, Inc.



Howard A. Acheson

Titanium Development In Canada

By JOHN F. SCHMUTZ, ChemE '55

Photographs Courtesy The Northern Miner

During the later stages of World War II, rapidly diminishing reserves of vital metals made it apparent that American industry had to look for new sources of such strategic materials as zinc, lead, aluminum, and nickel, or find suitable substitutes. Titanium metal showed great promise as a suitable substitute since it combines many of the important qualities of aluminum and steel. Although titanium oxide, with its superior hiding and spreading qualities, had been used as a white paint pigment since the early twenties, a process for the manufacture of titanium metal was not developed until 1946 when the Bureau of Mines announced its successful pilot plant experiments with the Kroll process (developed by Dr. Wilhelm Kroll, a Luxembourg chemist). In the interim between the research and production of the metal, titanium oxide was in great demand by the paint industry.

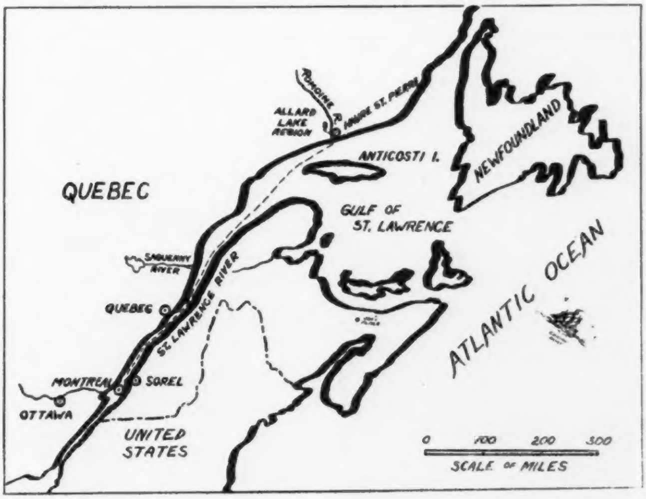
Before the uncovering of the great ilmenite mine at Lac Tio in the Allard Lake region of Quebec, titanium oxide ore came chiefly from Travancore, India, and the American mines of Du Pont, National Lead, Glidden, and American Cyanamid. These deposits, either at great distances from markets or of low grade ore, fell far short of the demand. Thus with an established product, titanium oxide, and a marketable new metal, titanium seemed a profitable and promising field for industry to explore.

The history of the Allard Lake region titanium deposits dates back to 1941 when Dr. J. A. Retty, working for the Quebec Bureau of Mines, followed up the scattered reports of a large ilmenite deposit in the Lower Romaine Valley of Quebec and explored the territory by canoe. This country lies at the mouth of the St. Lawrence River where it empties into the Gulf of St. Lawrence about four hundred miles below the city of Quebec. Here in Saguenay county among the many lakes and rivers north of the St. Lawrence River, Doctor Retty noted large masses of anorthosite rock, some rich in ilmenite. A very rapid examination of the water courses in this region indicated widespread presence of ilmenite.

Three years later, in 1944, when the report of Doctor Retty's findings was published, little interest was shown. Almost simultaneously several small syndicates, Simarck Syndicate, K. J. Springer and associates, and Bern Maytyn and Dan McRae, prospecting for Vital Minerals Prospecting Syndicate, staked claims, but for lack of finances, metallurgical know-how, and market outlets required, futher development was curtailed.

Kennecott Gains Options

It was here that Kennecott Copper Corporation entered the picture through their newly formed Canadian subsidiary Kennco Exploration, Ltd. Under the direction of A. H. Robertson, a well known Canadian mining engineer, Kennco obtained options from the groups already staked in the area and began exploration. Following a carefully plotted grid pattern, prospecting crews set out in the winter of 1946 to find the extent of the deposits,



Five-hundred-mile route to Sorel. Two 10,000-ton ore boats haul ilmenite from Havre St. Pierre to Sorel during the eight months the St. Lawrence is free of ice.

and a year later, having even used air-borne magnetometers to traverse 5,000 miles of unexplored land, the survey was completed. Results confirmed the presence of large ilmenite deposits, including the Cliff ore body on Tio Lake. Diamond drilling, begun in the winter of 1946 to ascertain the exact extent of the ore body, proved tremendous deposits of over 125 millions tons and possibly 300 million tons in the Allard Lake region and out 30 miles north of the St. Lawrence. On the Petit Pas ore body alone over 70 holes were sunk showing the ore to extend over 300 feet deep in some places and to have a maximum width of over 3500 feet. Further, millions of tons of ore lie on the surface, and for many years mining will be by surface excavation. The ore contains about 35% titanium oxide and about 40% iron. In comparison, ore from the famous McIntrye mine of the National Lead Company, which previously supplied most of the country's titanium oxide ore, contains about 18%-19% titanium oxide.

But it is a long way from the discovery to the finished product or even to the first mining operation. Before any mining was to be feasible, a suitable means for extraction of the titanium oxide from ilmenite had to be developed. Here the New Jersey Zinc Co., which had been carrying on titanium research since 1946, contributed an economical method of electrically smelting the previously inseparable ilmenite. In 1948 these two companies—Kennecott and New Jersey Zinc—merged their resources to form the Quebec Iron and Titanium Corp. Kennecott retained a two-thirds interest, N. J. Z., one-third.

1½-cubic yard shovel begins mining on the first bench at Grader Lake, south of the main ore body.

Diesel locomotive at "End of Steel". Construction crews had to push a railroad through 28 miles of this tough terrain.

Railroad Big Problem

Now began the $30 million job of mining the ore, building a railroad to bring it to the St. Lawrence, shipping it to the smelter, and construction of the huge electric arc furnaces to smelt the ore. Actual mining presented no problem since the overburden ranged from zero to only a few feet. Trees could be cleared, moss and dirt dug away, and ore scooped up by a 1½ cubic yard diesel shovel. The big problem was to transport the ore over the rocks and muskeg to the St. Lawrence. To do this Quebec Iron and Titanium built a 7½ million dollar railroad over the almost impassible twenty-eight miles from Lac Tio to the St. Lawrence. Going north from the loading port on the St. Lawrence—Harve St. Pierre—the railroad travels for two miles over level sand plain followed by three miles of muskeg and a 1600-foot span over the Romaine River. North of the Romaine the railroad cuts through four miles of muskeg, three miles of marine clay, and finally through fifteen miles of extremely difficult rock country. Since no gravel is available in most of this region all fill was obtained from rock cuts or borrow pits along the way. As an idea of the enormity of the project, 400,000 cubic yards of earth and sand, and 500,000 cubic yards of rock fill were needed to complete the twenty-eight treacherous miles. Besides this, 130,000 cubic yards of muskeg had to be excavated, and a 700-foot tunnel, a 1600-foot span across the Romaine River, and a 156-foot bridge across the Puyjalon River had to be built.

Meanwhile at Harve St. Pierre, the small fishing village at the terminus of the railroad, a 3½-million dollar construction began on loading docks, storage trestle, powerhouse, camps for the men, offices, and repair shops. Selection of Sorel, an industrial town fifty miles east of Montreal, as the site of the smelter, was governed by two prime requisites of the new plant: manpower and the tremendous quantities of electricity required for the furnaces. Here Shawinigan Water and Power contracted to supply power for the smelter whose furnaces consume 16,000 kilowatts each.

Long Trip From Mine to Smelter

Now let us follow the ore as it procedes from the mine to the smelter. It is initially scooped from the first open pit at Grader Lake just south of the main ore body by a 1½-cubic yard diesel shovel. From the pit it is transported by truck to the railroad, where it is loaded into ten-car trains of sixty-five-ton Steep-Rock type ore cars. Two 100-hp diesel-electric locomotives shuttle the loaded trains the twenty-eight miles to Harve St. Pierre, where they are pushed out onto the 574-foot ore trestle and dumped. Underground conveyors

siphon ore from the pile beneath the trestle and carry it onto the loading dock where a fixed boom tower loader loads the ore boat at at the unbelievable rate of 2000 to 2800 tons per hour. At the present time ore is carried up the St. Lawrence from Harve St. Pierre by two 10,000-ton leased freighters. A round trip from the loading dock to smelter and back can be made in six days. Diesel-electric power supplied by two 300-kw generators is used in operations at Harve St. Pierre, since the power consumption does not warrant the construction of a hydroelectric plant, and since sea-going tankers can adequately and economically supply the fuel needs.

At the 500-foot sheet pile dock at Sorel, a traveling Wellman unloader employs an 8-ton clamshell bucket to unload the ore. After unloading, the ore is carried by belt conveyors to the storage piles. Plans are to build a reserve storage pile of a half million tons at Sorel. Since the river is impassible for four or five months a year, all ore for the winter months must be stockpiled while the river is free of ice.

Ore and coal from the stockpiles are separately conveyed to a building where they are dried and crushed from a 2-inch size to 5/8 inches and then conveyed to the dry storage bins. A No. 2 buckwheat anthracite coal is used instead of coke because a more constant size with better physical properties is available, and the coal has a lower sulfur content than coke. From the storage bins the coal and ore are automatically weighed and mixed in a ratio of 15 parts of coal to 100 parts of ore, then fed into storage hoppers or directly into surge bins; these surge bins supply the 76 feeders in the top of the furnace.

Largest Electric Furnace

The furnace—one of five to be built in the near future— is the largest of its kind in the world. It is 54 feet long, 25 feet wide, and 11½ feet high; through the arched roof of the furnace protrude six 2½-foot graphite electrodes at 6½-foot centers. Current from three of the electrodes forms three arcs which curve down into the molten bath then back to the other three electrodes. The ore is fed continuously, by gravity, through 76 feeders spread in four rows along the chrom-magnesite sprung roof. As the ore is fed around the electrodes it melts at temperatures above 2900°F. Molten ore collects on a 25-foot hearth with the titanium slag floating on the top. The iron layer, usually twelve inches deep, is tapped every twelve hours, while the titanium oxide slag, varying from thirty to forty inches, is tapped every four hours. The furnace is operated as a sealed unit under slight pressure. One of the big problems in the smelter is finding a suitable refractory for the furnace lining. The hot titanium oxide slag, containing about 70% TiO_2, corrodes any known refractory. The problem has been partially solved by feeding the charge along the sides and end walls of the furnace, thus enclosing the melt in unmelted material and preventing digestion of the brick.

Slag containing about 70% TiO_2 is tapped at about 1600°F, cast into 50-pound cakes by a pig machine, cooled, and dumped outside the building. It is finally crushed to ½-inch size and sold f.o.b. Sorel. Oddly enough, the slag, which is destined to become one of the whitest pigments known, is black, as is the ore from which it originates. The slag also contains about 8% iron. This iron is a necessary constituent and acts as a flux which keeps the slag fluid. The more coal used in smelting, the less Fe_2O_3 is left in the titanium slag.

The iron tapped from the furnace is charged directly into a 60-ton electric refining furnace where it is desulfurized and cast into 23x25-inch ingots weighing 7000 to 9000 pounds each.

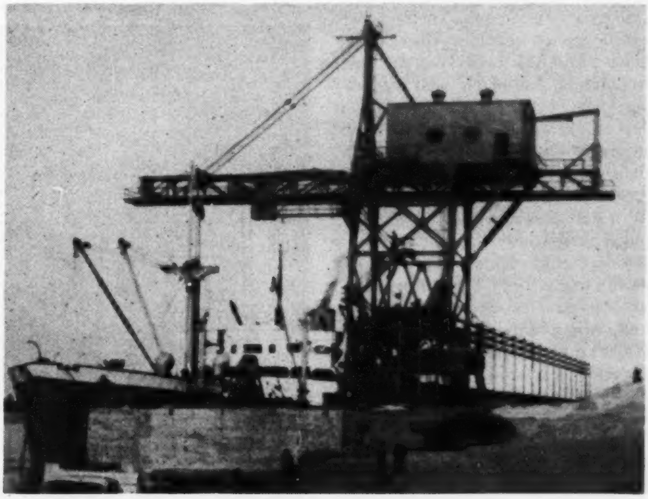
Now with only one furnace in operation production is somewhat less than 300 net tons a day, but by the time all five melting furnaces and two refining furnaces are in operation it is hoped that the smelter will have a daily consumption of 1500 tons of charged material. Of this, about 500 tons will be iron; slag will reach about 700 tons, the remaining 300 tons going off as CO which will replace the present oil as a fuel for drying the incoming ore.

Market Precedes Product

Now, what about the market? The iron is readily sold to the rapidly expanding steel industry around Montreal, while slag, which ultimately is expected to reach an annual value of five to ten million dollars, is already contracted for sale in the United States. Because of the acute shortage of lead, titanium has been rapidly replacing white lead as a pigment base. Titanium oxide also finds its way into numerous other industrial processes such as making paper opaque, making rubber white, ceramic glazes, in printing ink, in cosmetics, and in delustering artificial silk.

(Continued on page 52)

An 8-ton Wellman unloader empties an ore boat at Sorel.



SCIENCE and TOMORROW

By MARSHALL D. LAPP, EP '55

Photographs Courtesy Towne Studio

On last December 7 and 8, the University of Buffalo, a 105-year-old institution actively interested in stimulating the public, sponsored the Niagara Frontier Convocation on the theme "The Outlook for Mankind in the Next Half Century."

Among the many panels on themes varying from the next half century's progress in health, to the prospects for peace with freedom for the next fifty years, was one of particular interest to the readers of this magazine—"Will Science and Technology Transform Our Lives During the Next Fifty Years?"

Dr. Clifford C. Furnas, Director of the Cornell Aeronautical Laboratory, skillfully moderated the science and technology panel, introducing the speakers and offering pertinent remarks of his own.

Method of Prediction

The first speaker was Dr. George Russell Harrison, Dean of the School of Science of M.I.T. He began by explaining the method by which any scientific prediction is made. This method involves extrapolation, in which past events are plotted as curves and these curves extended to fall into the region of the future. Dr. Harrison then stated that he believed that science and technology would transform our lives about four times as much in the next fifty years as in the last fifty years. The average productivity of the American worker doubles every few years, and, when extended, this curve shows us that in 2000, the average American's output, and income along with it, will be eight times what it is today. The rapid increase in the number of educated men will also be a significant factor in the world of fifty years from now. At present, the number of physicists is doubling every eight years.

Dr. Harrison gave an interesting answer to those who question the wisdom of delving into the secrets of the atom. He would ask them, what of fire? Even though it can cook our meat, it can also burn down our homes, so would we be better off not having discovered fire? Regarding study of the atom, Dr. Harrison is optimistic; "The happiness will far outweigh the tragedy."

Dr. L. Grant Hector, Vice-President of the Sonotone Corporation, spoke next. The tone of his speech was set by his opening remarks. ". . . Man, himself, will change very little in the next fifty years . . . only the details (of life) will change. These details will seem most important to the individual, but probably will not have a great effect on his character or on the general social consciousness, in other words, on the development of civilization in the broadest sense." This viewpoint differs radically from those of several of the other speakers.

Better Than Nature

Among the changing details of life, Dr. Hector first mentioned that we are becoming less and less dependent on nature for many of our stables. He cited the textile fields as an excellent example of this. We now have rayon, nylon, and orlon to replace cotton and silk, and dacron to replace wool. Many new products which started simply as substitutes soon excelled the natural products in the ordinarily desired qualities and often developed new desirable qualities. The field of medicine is another fine example of this process. The gem industry offers a striking illustration. To tell the difference between a natural ruby and synthetic one, look for the defects. The gem with the defects is the natural one.

Besides improving upon nature,

The speakers at the panel on Technology in the Next 50 Years were, front left to right: Thomas D. Phillips, Charles C. Price, L. Grant Hector, George R. Harrison, Clifford C. Furnas, and (speaking) Alexander P. deSeversky.

changes are occurring in man-made devices. In the field of music, new instruments are slowly making headway. We already have the Hammond Organ and the Baldwin Electronic Organ competing with the accepted pipe organ. New musical instruments will be developed with tone qualities different from any of our present types.

Dr. Hector's views regarding atomic energy are of special note. He believes that although this form of energy is spectacular in that its source requires an extremely small space, it will never become practical where coal or oil are available. It may, however, be used in remote parts of the world and in ships or planes when it is desired that they go for long periods of time without refueling. From this, Dr. Hector points out that individual output and income of the worker will not increase from ". . . improved or cheaper sources of energy" but ". . . will improve almost entirely from. . . scientific development [of new products] and increased industrial efficiency."

In his own fields of physics and chemistry, Dr. Hector informed us that the greatest area of activity at present, which may give us an indication of the nature of things to expect in the future, is the physics of the solid state. The gaseous and liquid states have been explored to some detail, but much less is known about the solid state. One of the first products to come out of this increased research is the transistor, an amazing contender for the job of the vacuum tube. (CORNELL ENGINEER, Dec. 1951.) Much is expected from research of the solid state.

Climate Control

The third speaker was Dr. Thomas D. Phillips, Professor of Physics, Marietta College. Dr. Phillips believed that greater comfort and improved production will be the aims of technology. A new area will be climate control. We must, however, not dive into this blindly, since the problem of climate control is extremely complicated, and we do not know what the result of our efforts will be. Dr. Phillips cited the difficulty of the problem by stating that, in many cases, scientists are not sure which are causes and which are effects. "Is a dry treeless plain treeless because it is dry, or dry because it is treeless?"

In a more optimistic tone, Dr. Phillips told us that human physiology is the main field remaining open for new work in chemistry and physics. Cures for cancer, tuberculosis, and polio are immediate goals. Much time is being spent in the study of the deterioration of the human body. Although it is not likely that a great deal will be done in the prevention of such deterioration in the next fifty years, it is expected that a good deal of work will be done in the development of

Major deSeversky spoke of "atomic bicycles in a global community."

adequate substitutes for human organs. We already have artificial limbs, false teeth, spectacles, and hearing aids. Insulin, thyroxin, cortisone, and adrenalin can now be given by injection. The future looks bright, and it may not be too long before we have artificial hearts, lungs, kidneys, digestive tracts, and ductless glands. Such developments will be greatly accelerated if we are able to give the chemists and physicists more power and freedom in their medical pursuits.

Another area of scientific progress stems from the fact that a given event or phenomenon may be described in more than one way. Thus, a table top may be measured to be a certain number of square inches or a different number of "triangular" inches (area enclosed by a triangle one inch on each side). In the same manner, properties of matter are described by the wave theory where it is useful to do so, and by the quantum theory where the latter becomes more useful. Simply because two methods of description are used does not mean that either is incorrect. The social scientists must accept this more and more.

Dr. Phillips stated that although rearmament and atomic bombs will affect technology, they will not retard various non-military programs to any large degree. In relation to the atmosphere in which science and technology can best serve mankind, he was emphatic in saying ". . . There must be freedom to pursue the truth without hindrance and without fear of reprisal."

Living Standards Raised

The next speaker was Dr. Charles C. Price, Head of the Department of Chemistry, Notre Dame University. His initial main point was that "scientific development pyramids, . . .and (thus) scientific progress is. . . a continually accelerated process." Next, he emphasized the tremendous power of science and technology to develop the substandard areas of the world and to bring decent standards of living to the peoples of these areas. This will probably be the most effective economic and political influence of scientific and technological progress. In this same line of thought, increased knowledge of food technology in particular, including production, processing, and distribution, will free many from bondage to the soil for other useful endeavors. Education and medicine will give us beter health, and the world will settle down to a stable population of about 2.5 billion. The tropical diseases will be fought, and those regions used for agriculture.

The unifying force of science will also be felt quite strongly in the future, for "science is the same everywhere." More will be said about this later.

Major Alexander P. de Seversky, aeronautical consultant and inventor, spoke last. His opening remarks were the very opposite of Dr. Hector's. ". . .The nature of social-political relations on this planet—the very shape of society—will be basically altered before the end of

(Continued on page 46)

The Musical Valved Brass

By IRWIN B. MARGILOFF, ChemE '53

Photographs Courtesy The Music Department

"However," said the medieval medical man, "your weak lungs may possibly be made stronger if you take up the sackbut."

"Will it be painful, doctor?"

"I'm afraid there's a good chance that it will be."

At one time, secular instrumental music was regarded chiefly as a practical means of strengthening lungs, and as an accompaniment to the outdoor frolics and military functions. Playing the sackbut (the medieval form of the trombone) was sometimes prescribed for weak lungs because of the large amount of lung-power needed for its proper performance. Band music of the time was played on loud coarse instruments—or, more accurately, weapons—which were crude wooden affairs operated by very coarse reeds or the lips of the players. (Vocal music, on the other hand, had already attained a high degree of perfection.) The reed-operated instruments were the ancestors of the modern woodwinds. The lip-operated were the forerunners of the modern brass. One of the later, but still crude, brasses was the "serpent," which has been described as looking "like a disheveled drain-pipe suffering internally." It probably sounded like one. The serpent was a member of the keyed-brass series, about which more will be said later.

Originally, the brass provided martial music for outdoor occasions. During the eighteenth century the strings made up the indoor orchestra. Oboes and bassoons were then added, and later the clarinet and flute. Meanwhile the horn—the first of the orchestral brass—was introduced and promptly denounced as the possessor of a "crude and barbaric" tone. Now we very often think of it as having a "mellow" tone.

The Serpent. This has been described as "a disheveled drain-pipe suffering internally."

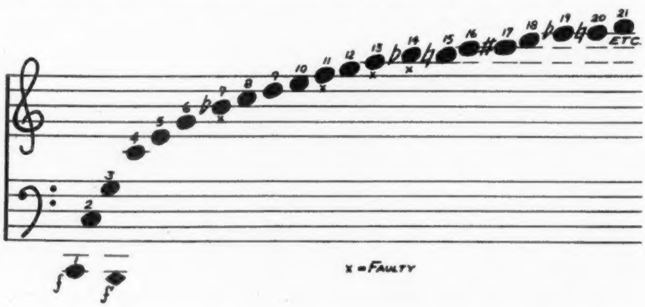
The horn will be discussed here, but these comments apply to the other brasses with suitable (but not fundamental) modifications for pitch, playing technique, etc.

Fundamental Principles

The horn waged a long fight in becoming an instrument fully capable of playing anything presented it, for this reason: Suppose a length of tubing possesses a mouthpiece over which a player may stretch his lips. When the lips are stretched properly, and when he blows into the tube, he may get the note *f* in Fig. 1. By gradually varying the force of his breath and the tightness of his lips across the mouthpiece, he may produce the rest of the notes in Fig. 1,—and only those notes. The range of the horn is from 2 to about 16.

(For the musically untrained,

Fig. 1. The harmonic series. The notes marked X do not fit into our musical scales.



Figures 1-4 serve as qualitative guides in the discussion. Also, note that harmonics 7, 11, 13, and 14 do not agree with our ideas of musical scales, and while they are just as satisfactory, physically, as the others in the series, they are not used in playing music.)

The numbers of the notes indicate the number of parts in which the column of air in the tube must vibrate to produce the notes. For note *f*, it must vibrate as a whole. For 2, it must vibrate in halves, for 3 in thirds, and so on. This is the harmonic series of the fundamental *f*. It is mathematically just as clear as musically, that the upper notes of the series are closer together than the lower, because the numerical difference between 1 and 1/2 is greater than the difference between 1/2 and 1/3. This holds also in the upper range, near 20, and as very high harmonics are reached, the intervals become smaller than the musical half-tone (which is the basis of all of our scales) and thus unsuitable for ordinary use.

But there is a limit to the strength of the player's breath, and the degree of tightness he can get in his lips. There is also a limit to his ability to differentiate between the lip pressures and breath pressures needed for the closely spaced higher notes. These limits determine the height of the playable notes above the fundamental. Anything above 21 is practically impossible on a brass instrument. So to take part in a performance, the player of a tube of this type must skip around on his small group of playable notes, and be satisfied with them. He cannot play a chromatic scale throughout the range of his instrument; that is, he cannot play all the notes that exist between 1 and the upper limit of his technique, for not all occur in any one harmonic series. All of the foregoing applies to vibrating strings, with the obvious differences that plucking or bowing will set the string in motion. The string will vibrate in the same fractions and will yield the same relative series of notes as a column of air in a hollow cavity.

Solution to Problems

One of the earliest and most successful solutions to the problem of constructing a chromatic brass instrument was the invention of the sackbut. In fact, the only apparent difference between the medieval sackbut and the modern trombone was the probable absence of the same seven "positions" of the trombone slide. When the slide of a trombone is moved, its column of air is altered in length, and produces a new series of harmonics corresponding to the new tube length. By the correct movement of the slide, all the intervening notes can be played (the whole series in Fig. 1 is moved to a new position), and the instrument is thus fully chromatic. In fact, after a discussion of

The Ophicleide. Used by Mendelssohn in "A Midsummer Night's Dream," and visible on the cover of Punch.

the valve system and its basic fault, the excellence of the trombone method will be very clear. Only the strings and the trombone are "untempered"—capable of adjusting very sensitively to new musical keys. All other instruments are not.

Another method of achieving a chromatic scale was to weld several tubes of individually set pitches together. This was abandoned because of the awkwardness of carrying so much metal around. One experimenter welded four separate horns together into one unit.

A system similar to the woodwinds was applied to the trumpet in these experiments. This takes advantage of the fact that a laterally bored hole in a tube ends the effective vibrating column of air at that point. Although this system of changing the notes which are producible provided great agility, the tones themselves were not accurately pitched, and were of poor quality. The serpent was a member of this family of brasses. The last of these keyed brasses to disappear was the ophicleide, which until the advent of the bassoon and tuba basses in the nineteenth century was used as the orchestral bass. The keyed trumpet was the instrument for which Haydn wrote his trumpet concerto. An unsuccessful keyed horn was also attempted.

One may ask—why were the keyed brasses necessarily off the correct pitch? The answer is that the lateral holes were operated by keys directly above them; these were operated by the fingers or by simple arrangements for transmitting the motion of the fingers. Since the player's hand could not be twisted into any position that might be acoustically desirable, compromises sometimes had to be made, and the lateral holes were sometimes bored with a view more towards anatomical than musical comfort.

With the nineteenth century development of better metal-working techniques, many of the standard instruments were improved, both in tone and agility. Instrument makers such as Adolphe Sax and Boehm perfected the familiar intricacies of rods and levers on the woodwinds which were necessary to allow the correct location of holes, yet allow the player to play the instrument with his fingers in normal positions. These new techniques might have eliminated the off-pitch defects in the keyed brass, but not the intonation, the quality of which was still far below that of the simpler unimproved brasses with unbroken tubes.

The Best Solution

Prior to the development of the valve system so familiar today, "crooks" were used to change the length of the effective air column. These were coils of tubing which, when inserted into the main tube of the instrument, changed the fundamental by altering the length of the combined tube. But when a

certain crook was in use, the player could play only those notes in the harmonic series of the fundamental produced by that crook, and none other. The convenience of the crook system was that instead of carrying a large number of complete horns, one horn and a sack of crooks would do. Crooks were also applied to the trumpet.

A major fault of the crook device is the lack of a single standard of lip tension, or embrochure. No matter what the tuning of the tube may be, the production of a tone which has a lower *number* in the harmonic series, will always be easier than the production of a harmonic which has a higher number. Thus, when the horn or trumpet on which he is playing is continually growing or shrinking, the player must adopt a different embrochure to play a note of the same number in the series of two fundamentals. And whenever the key is changed, the crook must be changed to play the notes in the new key. In *Don Giovanni* Mozart changes the tuning of the horns thirty-five times.

The early attempts to construct a fully chromatic and portable instrument were, then: 1. making a chromatic instrument too heavy for ordinary use (the four-horns-in-one),

2. making a portable instrument at the expense of chromatic ability (the crooks),

3. making an instrument both chromatic and portable, but with faulty intonation (the serpent, ophicleide, etc.).

At this point the topic of whole-tube and half-tube instruments must be introduced. If the taper of the bore is sufficiently wide, the tube will have the fundamental as its lowest note. But if the taper is slight and the tube is not sufficiently wide, then the first note that can be produced will be the first harmonic, or note number 2 in Fig. 1. With a very loose lip and low breath-pressure a very unsatisfactory fundamental can be produced; thus the designations half- and whole-tubes. The tuba is an example of a whole-tube. The horn trumpet, trombone and cornet are half-tubes. The tuba can yield its fundamental; the others cannot.

The Valve System

Finally, the valve idea was worked out and was applied first to the trumpet and then to the horn. The idea is quite simple, and may be thought of as a modification of the crook system.

Suppose a note from the tube corresponds to the fundamental f in Fig. 1 To get a note one half-tone lower (the diamond-shaped note f') the tube must be made longer. Accordingly, a tube is added with a connecting valve to the original; this will lower the fundamental of the combination of tubes one half-tone. A lowering of one whole-tone, or of three half-tones, is accomplished by adding corresponding lengths of tubing to the original with corresponding valves. These form the basis of the valve system.

Fig. 2. Descending fundamentals. All the black notes have been added to the horn's range.

If the tube will produce f_0 in Fig. 2, without any combined extra tubes, it will also produce the notes O, which are the first of the harmonics. If the half-tone tube is switched in, the fundamental will be f_1, and notes 1 will be playable When the second and third tubes are added, notes 2 and 3 will be available. With the proper method of connecting these extra lengths, so that they can be used in combination, the notes f_4, f_5, f_6, f_7, and 4, 5, 6, 7, complete the desired series, because

the three-halves (or one plus one-half) will yield f_3

the three-halves plus one-half will yield f_4

the three-halves plus one will yield f_5

the three-halves plus one plus one-half will yield f_6, and when all the tubes have been switched off the horn will produce f_7, the tubing for which has already been added. In other words, the horn is built in f_0, provided with a tube to produce f_7, and further provided with the means for proceeding stepwise down to f_7. All the notes in black in Fig. 2 have been added to the original compass.

Difficulties with Valves

But the introduction of the valve system was not as easy as the foregoing may seem, for while the individually added tubes may be at correct pitch when they are added to the main tube singly, they will *not* be at correct pitch if added in combination. What is to be done? Are the additions to be calculated on the basis of the main tube's length, the main tube plus the half-tone addition, or what? Whatever is done, the resulting notes made by the combinations will not be in tune.

Rather than abandon such a promising invention, many schemes have been worked out to correct the basic faults of the valves. There are the *Sax Six-Valve Independent System*, which employs a separate tube for each descending fundamental, the *Rudall-Carte-Klussmann System*, which uses conically-shaped additions, instead of the cylindrical ones used in the other systems, and many other systems of "compensating" valves, which automatically correct the inaccuracies in the combinations of valves.

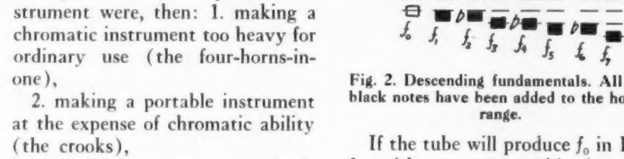
Trombones and Tubes

Throughout the history of the horn the trombone has not changed, because it has always been able to change the length of the vibrating air-column merely by pushing its slide in or out. The seven positions of the trombone are identical in responsibility to the seven combinations of valves on the valved brass.

When the valve system is applied to the tuba—a whole-tube instrument—there remains a gap of several notes between the fundamental, which is the lowest possible

(*Continued on page* 38)

Fig. 3. Four valves are required to descend to the tuba's fundamental.



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about tool steel forgings

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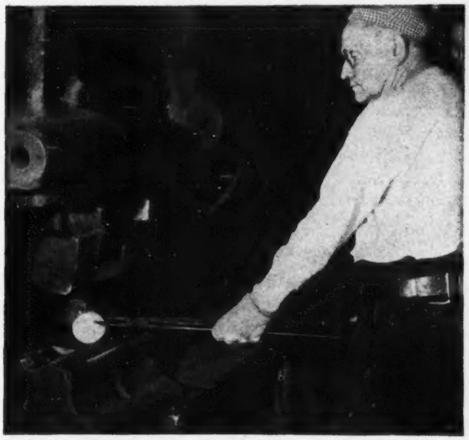
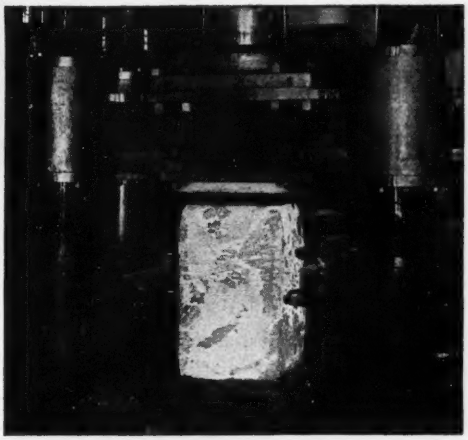
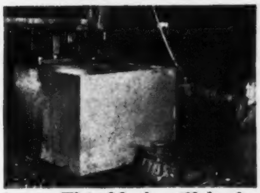




Rex M-2 High Speed Steel Disc Forging (1½ pounds)

Pancake forgings such as these are used extensively by small tool makers. Extreme care is taken in the preparation of the slug stock. The upsetting insures proper flow lines. Milling cutters, gear shavers and similar cutting tools that require maximum toughness, coupled with the best cutting ability, are made from these forgings.



CSM-2 Plastic Mold Forging (14,000 pounds)

This CSM-2 plastic mold steel forging was made from a 25,000-pound ingot. This block will be heat-treated and worked to produce a mold for the manufacture of large plastic parts. The finished weight of the forging is 14,000 pounds. And it is the largest mold forging yet produced by Crucible.

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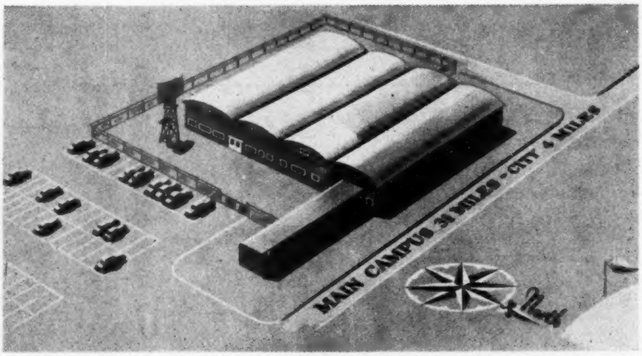
COLLEGE NEWS

GE Establishes Lab Here



It has been announced recently that the General Electric Company will establish an advanced electronics center at Cornell University, to be located near the Ithaca East Hill Airport, only a few miles from the main Cornell campus.

A pioneer venture in educational and industrial research cooperation, it is aimed at carrying out advanced study and development in the electronics field while providing scientists and engineers unique teaching and educational opportunities. It is estimated that about 80 scientists and technicians will be employed at the center during 1952.

Pictured here is an artists sketch of the laboratory, illustrating its extensive layout.

Kantrowitz at Harvard

Professor Arthur Kantrowitz of the Graduate School of Aeronautical Engineering has been appointed visiting lecturer in fluid mechanics at Harvard's Division of Engineering Sciences. He will teach a course in gas dynamics and also be responsible for a seminar taking up such problems as jet propulsion and chemical kinetics.

Two other faculty members of the Aeronautics School in recent news were Professor W. R. Sears, director of the school, and Associate Professor Nicholas Rott. Professor Sears presided as chairman of the aerodynamics session of the recent meeting of the Institute of the Aeronautical Sciences. The meeting was held in New York an January 28. Professor Rott presented a paper prepared by Lewis Crabtree, a graduate student, and himself. The paper concerned "Simplified Calulations of Three Dimensional Boundry Layers."

New Gaging Test

In order to overcome a lack of up-to-date material in the field of gaging, a new text has been put out by members of the Department of Materials Processing. The 127 page publication is at present available in mimeographed form. It illustrates the more common industrial measuring devices and describes and depicts working principles of equipment from micrometers to ultra-precise comparators. A more advanced manual considering quality control techniques, automatic sorting, and specialized techniques, is planned by the authors, Professor R. L. Geer and A. S. Dispensa. Professor Geer has developed a special laboratory containing $80,000 worth of gaging instruments. When installed in the new Materials Processing Laboratory, it will permit measurements to a few millionths of an inch.

Gillett Memorial Lecture

The American Society for Testing Materials has announced the establishment of an annual H. W. Gillett Memorial Lecture.

Commemorating Dr. Horace W. Gillett of the class of 1906, the lecture will be delivered annually at a meeting of the society. The lecturer, who will be selected through a committee appointed by the society's board of directors, will cover a subject pertaining to the development, testing, evaluation and application of metals and alloys.

Dr. Gillett, who received the Ph. D. degree at Cornell in 1910, was long a member of the society and was the first director of the Battelle Memorial Institute, Columbus, Ohio, which is cooperating to sponsor the lecture.

Engineering Log Book

The Student Engineering Council has organized a plan which, it is hoped, will prevent conflicts in the activities of the numerous engineering groups and societies on the campus. A log book, in which will be recorded all future meetings and projects of the various organizations, is being placed in the Engineer's Lounge in Sibley basement. Groups will be able to consult this centrally located log when planning their activities ahead of time and thereby keep to eliminate unnecessary difficulties arising from conflits.

ASCE Lecture

Mr. E. J. Swatek, a Cornell alumnus and chief design engineer for the contracting division of Dravo Corporation, was guest speaker at the meeting of the Ithaca section of ASCE on January 28. The meeting was held in Willard Straight Hall after a dinner for the members. The meeting was also attended by the student chapter. Mr. Swatek spoke on the construction of Monongahela River lock of which he was chief designer.

TECHNIBRIEFS

Carbide Twist Drills

Comprehensive laboratory tests, followed by actual production applications over extended periods of time, have now clearly demonstrated that cemented carbide twist drills can drill holes in cast iron at least twice as fast as high speed steel drills. At these higher speeds drill life is roughly three to four times that of steel drills. In addition it has been demonstrated that carbide drills can be used to advantage even where increased speeds are not possible. Operating at the same speeds, they give a tool life around ten times that of high speed steel drills.

A typical carbide-tipped twist drill is made simply by inserting a standard carbide twist drill tip in the end of a conventional high speed steel twist drill.

With this type of drill, consistently uniform results are now being obtained, using the same drilling equipment as was formerly used with high speed steel drills. Precautions to be taken, as far as machine and fixture conditions are concerned, do not differ from good practice for high speed steel drilling. Prime requirement—if it is desired to take advantage of the increased drilling speeds and feeds made possible by carbides—would be that the drilling equipment simply have enough power to take care of the increased rate of chip removal.

New Type Mounting

High-precision controls and other devices for jet aircraft of the future may be nearly shock-proof as a result of a new "center-of-gravity" type mounting.

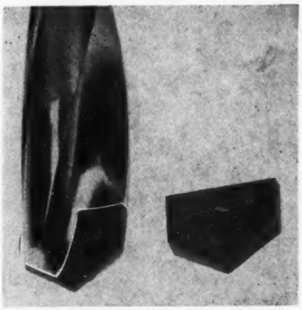
The new mount, designed to isolate the controls from vibration and shock encountered in modern high-speed aircraft, was developed by General Electirc Company engineers at Schenectady, N.Y., with the co-operation of the Naval Bureau of Aeronautics. It resembles a small platform suspended by a coil spring at each of its four corners.

Key to its effective operation is the location of the control to be protected. The control is placed on the mount so that its center of gravity is an equal distance from each of the four supporting springs, and in the same geometric plane. This eliminates unbalanced movement and enables the springs to withstand shock from any direction, they said.

In addition, each spring is constructed of metal layers of different thicknesses. These layers have widely differing reactions to vibration so they tend to "snub" or neutralize one another and thus eliminate resonant vibrations.

In their first use in aircraft, the new mounts will carry G-E voltage regulators, devices which maintain a constant output of electric power for the plane's generators—all-important in highly-electrified modern aircraft.

About the size of a box camera, it weighs 3½ pounds when at rest. Under shock conditions, however, this weight is multiplied greatly as forces equal to ten times the earth's gravitational pull are exerted. This much force, engineers explained, might be encountered in extreme shock during landing, pulling out of a steep dive, or in a sharp turn.



A conventional high speed twist drill with carbide insert.

All-Glass Paper

Paper composed entirely of glass fibers, with no additive, has been made for the first time at the National Bureau of Standards, in cooperation with the Naval Research Laboratory.

The all-glass paper has several important applications. As an air-filter paper, tests show the new paper to be many times more effective than present commerical filters. It seems particularly valuable for gas masks and respirators used by firefighters, industrial and medical workers, and military personnel. In gas-mask tests in a smoke-filled room, only one smoke particle in 100,000 passed through the glass-paper filter.

Until now, many air filters have relied considerably on imported raw materials. Glass, however, can be produced from raw materials found abundantly in the United States.

Another important advantage of the all-glass paper is its high resistance to effects of heat, moisture, chemicals and micro-organisms. It has excellent electrical characteristics and should be valuable as an insulator and dielectric. For instance, it can be used to make oil-impregnated paper capacitors capable of operating even at temperatures above 200°C; suitable oils are available which withstand such temperatures, but the kraft paper commonly used is unsatisfactory for prolonged operation at temperatures much above 100°C.

In the manufacture of ordinary paper, vegetable fibers are processed with water in a "beater," which bruises the fibers and forms minute fibrillae. Prolonged beating reduces some of the cellulose to a gelatinous substance that cements the fibers together and strengthens the paper. With glass, on the other hand, bruising tends to weaken the paper, and no binding agent is

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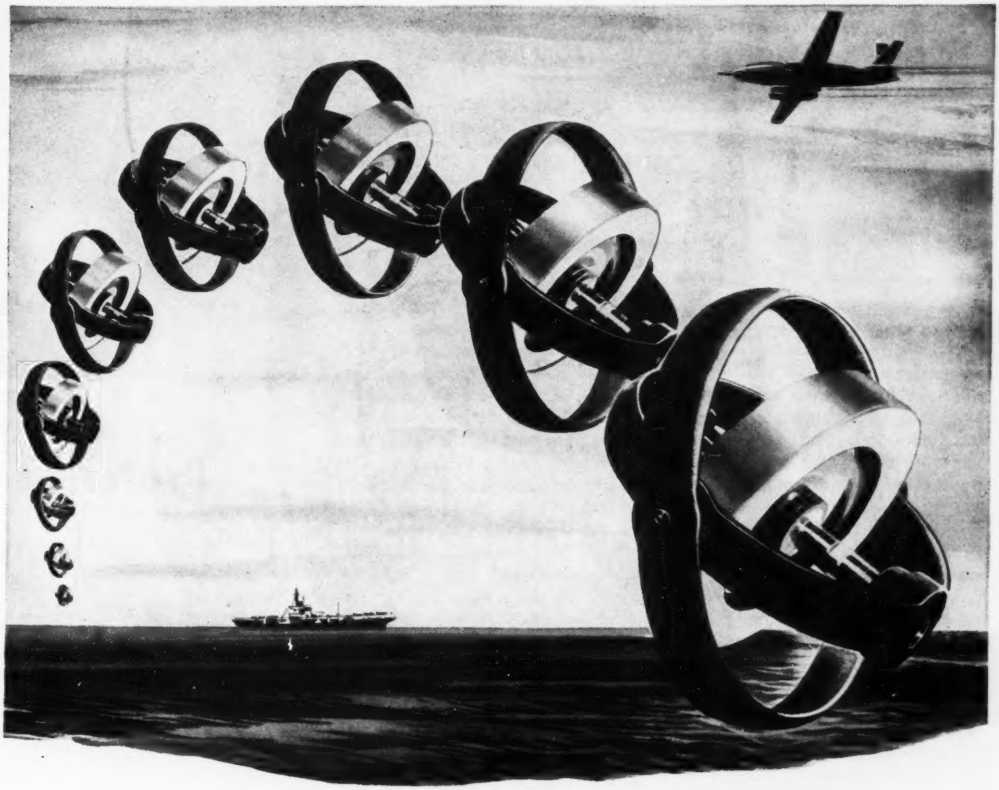
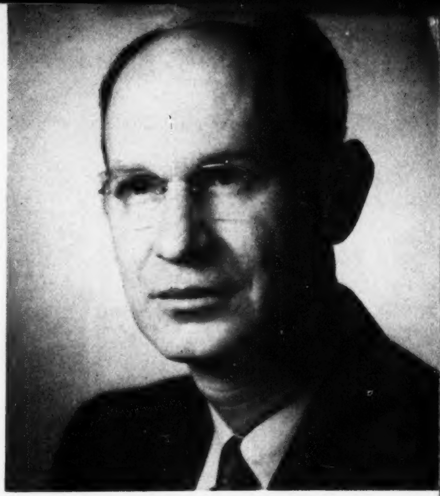


Faculty Profile

By JANICE BUTTON EP '54



Professor T. R. Cuykendall

The Engineering Physics school, youngest of the family in the Engineering College, has for its Assistant Director a man who exemplifies in his training and experiences the wide range of interests and high ideals of the school he helped to organize. Though busily engaged in teaching and administrative duties, Prof. Trevor Rhys Cuykendall has made significant contributions to various fields of science and engineering.

Prof. Cuykendall's formal schooling was of a nature to make him well-qualified for teaching and advising students in such a school as Engineering Physics. A graduate of the University of Denver in Colorado with a B.S. degree in electrical engineering, he worked briefly for Western Electric Company in Chicago and then returned to the University of Denver for his M.S. degree in physics. He had two years' experience as an engineering mathematics instructor at Denver and spent one summer studying physics and math at the University of California in Berkeley.

Prof. Cuykendall came east to Cornell with a teaching assistantship in physics. He was soon promoted to the postion of instructor, and in 1935 he received his Ph.D. in physics, his thesis being concerned with X-ray work.

Far from being just another engineer-turned-physicist, however, Prof. Cuykendall has delved into many different realms of science. He is probably best known for his work in mechanics, in which field sophomore E. P.'s first come in contact with him, although he did not specialize in this phase of engineering before the completion of his graduate study. His interest in mechanics resulted in five weeks of intensive study in a special summer course on properties of materials at M.I.T. in 1937. Since that time, the professor has been engaged in various research and construction programs. As a consultant to the U.S. Engineer Department, he played an important role in the building of Whitney Point Dam and Washington National Airport, for which he analyzed foundation stresses in earth embankments with the use of gelatin as a photoelastic medium. In another pre-war job, he collaborated with Professor Winter of the C.E. school in research on characteristics of lightweight structural shapes for the American Iron and Steel Institute.

In 1941 Prof. Cuykendall took a leave of absence from Cornell to make a direct contribution to the war effort. For two and a half years he was a senior physicist with the Naval Ordnance Laboratory in Washington, D. C., where he was engaged in the development of magnetometers — devices which, by measurement of small variations in the earth's field, can be utilized for detection purposes. Subsequently, he went to Los Alamos, New Mexico, where he participated in research, much of which is still classified.

Since his return to Cornell in November of 1945, Prof. Cuykendall has done consulting work for the National Bronze and Aluminum Foundry Company and for Oak Ridge National Laboratories in addition to studying fatigue of ship welds. In collaboration with Prof. Henri Sack of the physics department here at Cornell, he has done a considerable amount of research in the determination of soil moisture and density by gamma-ray and neutron scattering. Results have been published in two reports of the Civil Aeronautics Adminis-

(Continued on page 26)

Profile

(Conitnued from page 24)

tration, and studies are still going on. Other research, also with Prof. Sack, has concerned the investigation of internal friction and anelastic properties of materials.

Prof. Cuykendall has found relief from his strenuous professional life in such hobbies as hiking and color photography. Mountain-climbing on peaks in Colorado and some of the San Juan range in New Mexico has afforded him much pleasure and enabled him to add to his mineral collection.

Prof. Cuykendall's home boasts a fair-sized wood-working shop where his son, who is just beginning high school, spends much of his time. Another possession is a phonograph built by the professor which has amplifiers of unusual design giving high fidelity with a small speaker. Prof. Cuykendall's interest in music, which dates from the days when he played trumpet in the University of Denver orchestra and band, has resulted in the collection of a fine library of records.

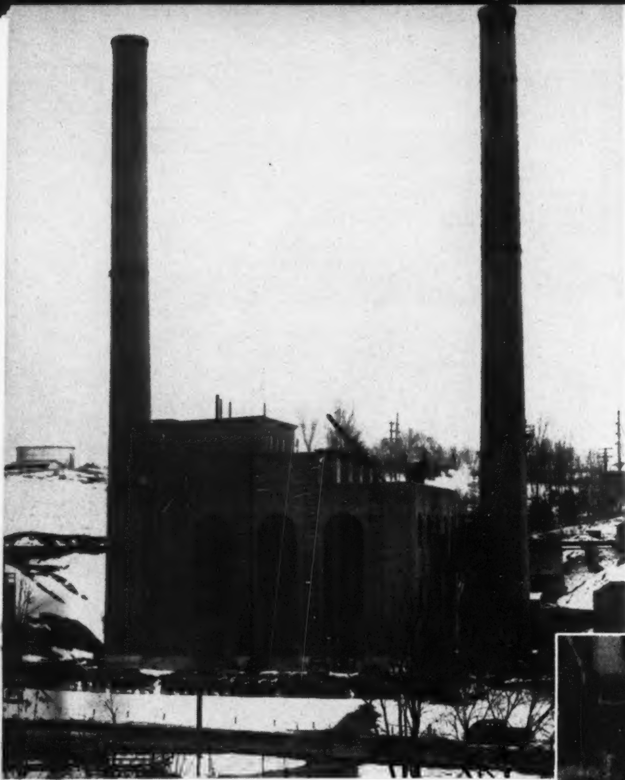
Besides instructing fourth-term E.P.'s in Strength of Materials and directing the work of a number of fifth-year students and graduates, he has also acted as a class adviser and has assisted many E.P.'s in obtaining summer jobs and permanent employment. The training and experience which enabled Prof. Cuykendall, with Dean Hollister and the school director, Lloyd P. Smith, to set up such a fine program as Engineering Physics, make the professor's help invaluable in contacts between students and industry.

Further evidence of Prof. Cuykendall's teaching ability was his engagement by the Oak Ridge School of Reactor Technology as a visiting professor for the fall term of 1950. While there he carried on a research problem in connection with the Oak Ridge reactor and helped to train young scientists for the sort of work in which many of his Cornell students may eventually be employed.

Prof. Cuykendall's ability and achievements have been recognized by Sigma Xi, Phi Kappa Phi, and Kappa Delta Pi, education honorary. For his work during the war he was honored by the Naval Ordnance Development Award.

Publications by Prof. Cuykendall, whose professional affiliations include membership in the American Physical Society and the American Association of University Professors, number some fifteen papers on such topics as X-ray absorption, the determination of very short time intervals, photoelastic analysis of foundations for earth dams, temperature dependence of Young's Modulus, and high-voltage cathode-ray oscilloscopes. These are indicative of his wide range of interests which have taken him into so many fields of science.

Professor Cuykendall's purpose, as well the goal of the Engineering Physics school as a whole — the "application of the methods of physical science to engineering problems"—has been admirably fulfilled.



BEHIND THE SCENES IN

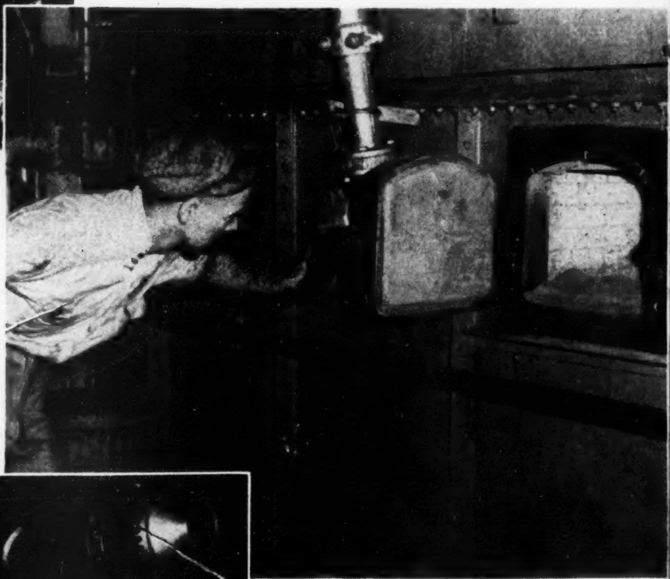
CORNELL'S PC

Two branches of Cornell University which receive
which are constantly supplying a valuable service to t
the Department of Buildings and Grounds. These divis
plants which together supply most of the steam heat a
quarters of its electric power.

Of the average 700,000 KWH of electrical energ
are supplied by the steam plant's power substation an
remaining 200,000 KWH are generated by the Itha
Although several buildings have their own heating fac
the heating plant.

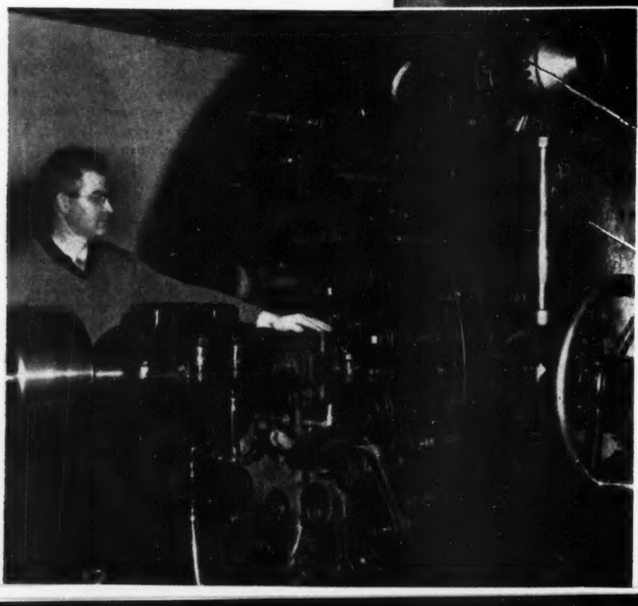
This highly automatic heat and electric power sys
guard against breakdowns.

The pictures included on these pages show some o
power and illustrate the maintenance operations neces



Above: Cornell's steam plant as viewed from Kite Hill.

Below: Ken Rosencrans checks the temperature of a bearing on the main shaft of a water turbine at the University's hydroelectric plant.



Above: Fireman, Kenneth Neube fire heating one of the boilers in the s

Above: Prope to the operation o generating system speed governor c

OWER PLANTS

By ROBERT M. STUCKELMAN, EE '54

very little attention by the faculty and students, but
hem are the Heat and Power Generation Divisions of
ions operate one steam plant and two hydro-electric
nd hot water used by the University and about three

y used each month at Cornell, about 100,000 KWH
d 400,000 KWH by the two hydro-electric plants. The
ca branch of the New York Gas and Electric Company.
ilities, most of the heat for the University is supplied by

tem runs smoothly, but requires constant vigilance to

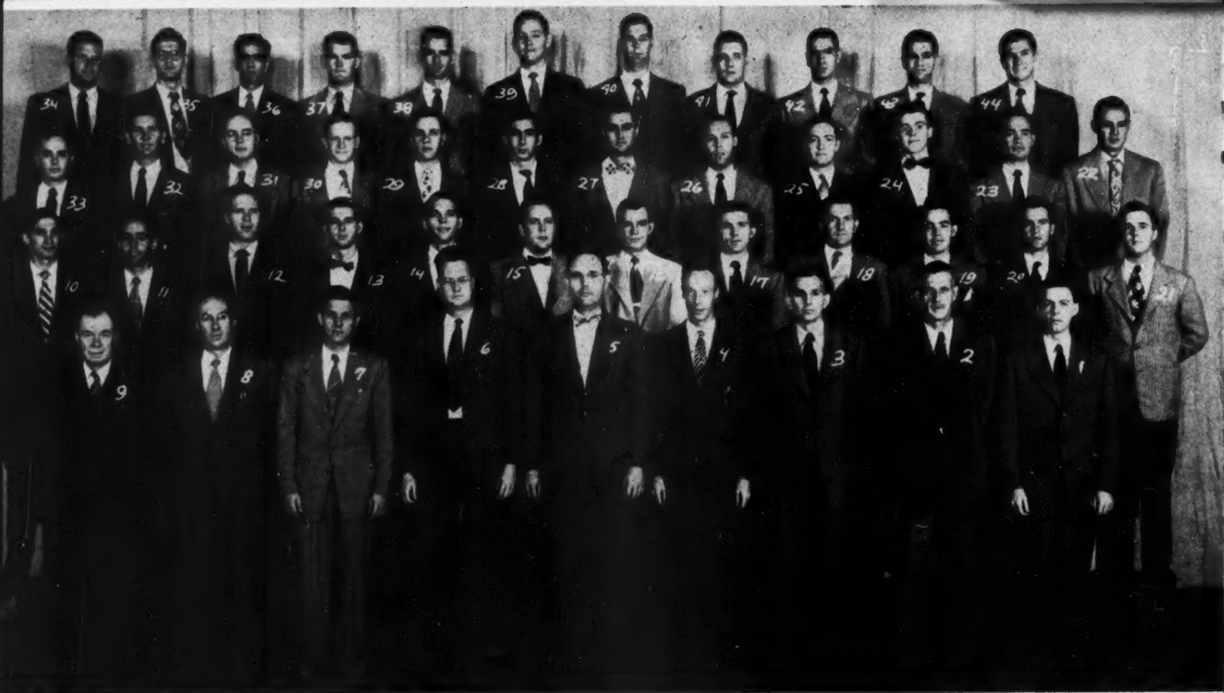
f the equipment used to produce heat and electric
sary for continuous operation.

Above: At the steam plant, Kenneth Neubert adjusts control settings for the Diely Boiler which produces 250,000 pounds of steam per hour.

Below: Engineer, Harold Terwillegar, checks the 215 KW steam turbo-generator which is part of the electric power generating system.

r inspects the
team plant.

r care of the governors is essential
f Cornell's highly automatic power
. Here, Ken Rosencrans oils a load-
t one of the hydro-electric plants.



—Photoscience

School of Chemical & Metallurgical Engineering

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2. Mason, C. W. (Prof.)
3. Hedrick, J. E. (Prof.)
4. VonBerg, R. L. (Prof.)
5. Burton, M. S. (Prof.)
6. Smith, J. C. (Prof.)
7. Wiegandt, H. F. (Prof.)
8. Winding, C. C. (Prof.)
9. Rhodes, F. H. (Prof.) Director
10. Riccardo, A. E.
11. Engel, A. J.
12. Schuh, C. R.
13. Henriques, H. P. III
14. Smith, D. M.
15. Darby, C. H., Jr.
16. Widener, P. L.
17. Murphy, R. W.
18. Kasbohm, M. L.
19. Seibel, A. D.
20. Rich, W. W.
21. Clarke, D. W.
22. Danly, D. E.
23. Nelson, R. T.
24. Pulver, D. R.
25. Taylor, W. P.
26. Ross, K. R.
27. Wannamaker, W. W., III
28. Emanuel, A. G.
29. Spiller, C. A., Jr.
30. Thorne, H. C., Jr.
31. Johnson, B. M.
32. Walker, V. A.
33. Abraham, W. A.
34. Mounts, R.D.
35. Forbes, R. H.
36. Hanesian, D. V.
37. Mehler, G. J.
38. Montgomery, R. J.
39. Field, F. R., Jr.
40. Bartels, H. J.
41. Mead, G. F.
42. Parker, R. H.
43. Steen, H. W.
44. Chernoff, B. I.

Department of Engineering Physics

—Photoscience

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2. Petschek, H. E.
3. Cuykendall, T. R. (Prof.)
4. Cromack, J. C.
5. Nelson, R. L.
6. Messiter, A. F.
7. Hartlieb, R. J., Jr.
8. Glick, H. S.
9. Szass, P. C.
10. Howland, L. P.
11. Hart, H. R., Jr.
12. Goldman, P.
13. Sherman, P. M.
14. Drake, F. D.
15. Goundry, R. A.
16. Livingston, J. D.
17. Zucker, M. S.
18. Zuk, P.
19. Estabrook, L. H.

An All-Season Ventilating System

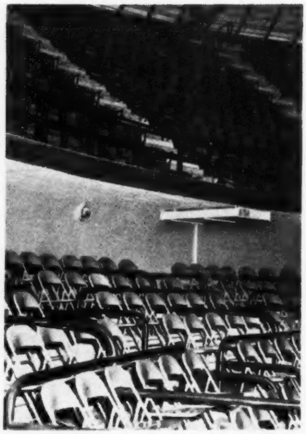
Photographs Courtesy Dravo Corporation

When the first show of the San Antonio Livestock Exposition was held last year in the new Bexar County Coliseum, San Antonio, Texas, spectators and exhibitors found the huge oval-shaped structure was equipped with a unique heating and ventilating system that maintains comfortable temperatures the year around.

Designers of the massive building, which is used for all types of athletic events, as well as rodeo productions and livestock exhibitions, overcame many of the problems of heating and ventilating by transforming the space under the balcony tiers into a large air chamber. In this chamber, pressurized air is collected for distribution into the amphitheater. During cold weather, the air is heated by 16 gas-fired "Counteflo" heaters, developed by Dravo Corporation of Pittsburgh. During the summer, only the heater

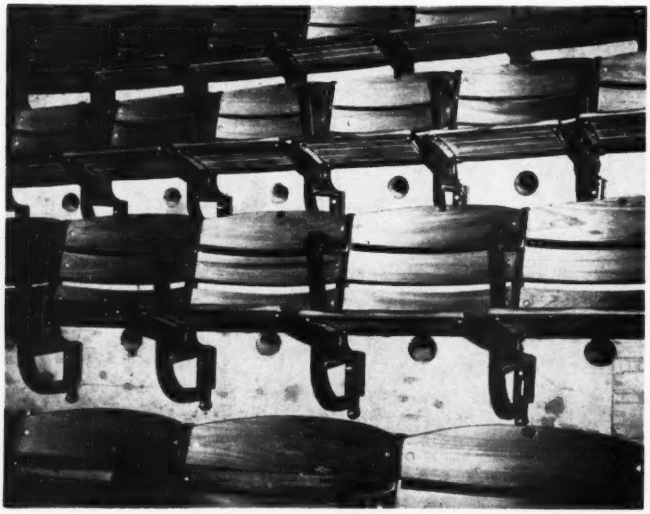
A large amphitheater in Texas is air-conditioned using the space under the balcony tiers as an air reservoir.

Each balcony seat has its own air outlet.



Air supply ducts leading from the unused area back of the balcony are shown above the box seats.

Forced air supply outlets under each seat. Each balcony seat has an individual air supply outlet.



fans are operated to help ventilate the building.

Each of the 5996 balcony seats, in effect, has its individual heating and ventilating system. In the reinforced concrete risers of each balcony tier are air discharge outlets spaced about 20 in. apart. These outlets, 3-in. pipe sleeves that were set in the forms before the concrete was poured, carry air from the plenum chamber behind the balcony into the arena.

The box seats, which accommodate 1560, encircle the arena of the coliseum. They are supplied with air through 24 ducts extending from the heaters to 40 in. by 6 in. grille openings above and just behind the box seat area. Similar ducts transport air to the big bandstand over the rodeo entrance at the north end of the building.

There are no piers, columns or other view-obstructing structural supports in the building, making

(*Continued on page* 44)

BOOK REVIEW

A New Text Treats Materials In a New Way

MECHANICS OF MATERIALS, *by Harry D. Conway, Professor, Department of Mechanics, Cornell University. ix+325 pp; Prentice Hall, New York,* 1950. $4.75.

The content of many traditional textbooks entitled "Mechanics of Materials" or "Strength of Materials," may well be more accurately described as the *statics of deformable elastic bodies* in that it treats the stresses and deflections of certain special shapes (rods, beams, columns) under simplified loads and is generally satisfied when a formula relating stress to loading and dimensions is achieved. This rather restricted point of view has been handed down to us from the great school of French mathematicians of the early 19th century who developed the subject; they had little, if any, consideration for those actual properties of materials and their mechanism of failure so important in present day design. Since the subject was, they believed, of practical importance, their development became known as the *resistance de materiaux,* a title still in use today.

By clearly stating the basic assumptions upon which the development of a given formula is based, and emphasizing the limitations of the textbook formula which may exist in predicting the behavior of real materials, Professor Conway has gone far toward eliminating the major difficulty in teaching a course of this type—namely, to maintain the proper relation of the traditional treatment of this material to present day overall design considerations. This perspective is set forth very briefly in Par. 1-1 and the elastic nature of certain materials is described in 1-6; the instructor using the text could well expand both these sections to provide a more solid frame of reference for the main content of the book. The introductory chapter includes sections on stress concentration factors and residual stresses; both are stimulating and valuable in properly orienting the student and in stimulating his imagination.

The style of this book is terse and "meaty". In many instances the reader will find it wise to cogitate over a sentence to develop its full meaning. This, plus briefly stated qualifications and extensions of formulae, etc., presents a real challenge to the intellectual acuity and imagination of the student. The order of presentation of the subdivisions is, to my mind, logical. Many illustrative examples are given. The figures are large and exceptionally well drawn to illustrate the principles under discussion. A number of pertinent literature references are given; this novel feature also should serve to stimulate the curiosity of the reader. An adequate number of problems are available at the end of each chapter.

In Chapter 2 the general case of combined stresses is developed smoothly from two simple cases. It is left for the student to see that the general case reduces simply to any special case by setting particular stresses equal to zero in the equation. After treatment of Principal Stresses in Chapter 2 there seems to be a reluctance elsewhere to step up and name a normal stress as a principal stress. (See, for example, the torsion of a shaft, page 66.) There seems to be no discussion of combined bending and shear stress at points near the ends of beams. In the main, however, the content is as complete as is possible in an elementary text of this type, and the presentation is strikingly clear and logical.

The chapter on "Miscellaneous Beams" presents a wide variety of stimulating problems, including flat spiral springs, crane hooks, and bending for non-linear stress-strain law. A wealth of very interesting material is contained therein.

The Euler column equation is neatly developed at the beginning of chapter 10, and its limitations are clearly described. Justification of various design formula is given This reviewer believes a hint about recent developments by F. R. Shanley would be appropriate at the end of this chapter.

Strain energy concepts for each type of stress are treated along with the general discussion of that stress state; Castigliano's theorem is in a separate chapter near the end of the book. No attention is called to the fact that strain energy cannot be computed by superposition methods. Perhaps this is left as an exercise for the reader.

A minor criticism is that in several cases the figure involved is on the reverse side of the page from the descriptive matter.

Professor Conway is to be congratulated for the preparation of this very readable text.

T. R. Cuykendall
Professor of Engineering Physics

Technibriefs

(*Continued from page 22*)

formed.

To get maximum strength and optimum air resistance, NBS experimented with different concentrations and beating times. A one percent glass concentration in the glass-and-water beater stock gave a stronger paper than higher concentrations, but further dilution had no advantage. Short beating times—just long enough to separate the glass fibers—were best.

Commercial glass fibers of finest diameter—grades of 0.75 microns (about 30 millionths of an inch) or less in size—gave papers with the best strength and filtering characteristics. Other experiments indicated that the strength depends on the presence of fibers of assorted lengths, but that very short fibers weaken the paper if present in substantial quanities. A sample of the water-fiber mix from the beater was run through a pulp classifier having screens of 65, 100, 150, and 200 mesh. Hand sheets made from fibers retained by a 65-mesh screen had only about one-fourth the tensile strength of the original paper, and hand sheets made from the combination of the 100, 150, and 200 mesh fibers were even weaker. But when paper was made of a mixture of fibers from all four screens, its tensile strength was 10 times greater than that of the original paper. This remarkable increase in strength apparently resulted from the removal of the "fines" (or "fillers")— the fibers that pass through the 200-mesh screen.

Jet Propelled "Lab"

The nation's first jet-propelled "laboratory" for high-speed flight testing of turbojet engines of advanced design has been placed in full scale operation by the General Electric Company.

The Company's Flight Test Division disclosed today that the "jet laboratory", a four-jet North American B-45 bomber carrying a fifth test engine in a specially-designed nacelle under the bomb-bay, was first flown in preliminary tests several months ago. The bomber was assigned by the U. S. Air Force to the company to flight test new jet engines developed by the G-E Aircraft Gas Turbine Department at Lockland, Ohio, at speeds never before attained in such operations.

The "jet laboratory," based at the company's Flight Test Center, Schenectady, N.Y., joins a fleet of specially equipped planes used to flight test aircraft equipment under development for the Armed Forces. These include a Boeing B-29 "Flying Laboratory", another B-45 which is being flown on an accelerated program to evaluate the service life of G-E J-47 engines, and a Lockheed F-94 fighter used to test automatic flight control equipment.

The engine nacelle of the jet laboratory, partially retractable into the bomb-bay when not in use, will accomodate turbojet engines considerably larger than any yet announced.

Valved Brass

(Continued from page 18)

note and the seventh lowering of the first harmonic. This is remedied by adding a fourth valve, with a value of five half-tones, to the tuba. This will provide the variety of combinations needed to go stepwise down to the fundamental from the first harmonic. It is interesting to note that the Big Red Band has no true tubas. All of its brass basses are Sousaphones with three valves. This fact, together with the fact that they can produce a very miserable and musically unsatisfactory fundamental note (which sounds just as miserable on the other half-tubes) shows that they are half-tubes, and cannot be true tubas.

With the help of the valves, the agility of the instrument becomes greatly enhanced. When the player wishes to produce a given note, he usually has several possibilities presented to him through the various valve combinations, since one note may appear in a number of harmonic series. He chooses the note in the series nearest to the one he is playing in at that moment. The valves detract somewhat from the tonal purity, for the old natural instrument in one key produced the notes in that key in perfect tune, while the valve horn has been tempered to yield notes in every key.

Thus we have lost one instrument and have gained another, almost identical with the first in tone, capable of everything the first could do, and able to handle, in addition, a more complex harmonic part in the work of the orchestra.

Fig. 4. The same notes are obtainable from several fundamentals.

Four books form the sources and further references for this article. They are:

Carse—Musical Wind Instruments (Macmillan, London, 1939)

Forsyth—Orchestration (Macmillan, London, 1914)

Sachs—Real-lexikon der Musikinstrumenten (Julius Bard, Berlin, 1913)

Sachs—Handbuch der Musikinstrumentenkunde (Breitkopf & Härtel, Leipzig, 1920)

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"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students and to establish closer relationship between the college and the alumni."

For no good reason some professional people develop a persistently negative approach. This may be one of the inherent evils of specialized knowledge—of knowing too much. If so, then I hope our 5-year curricula will have a broadening effect as it was planned to have and that Cornell engineers will be known for their willingness to say "can do".

This professional negativeness shows itself all over the place—with engineers, architects, doctors, lawyers and even plumbers.

Its worst manifestation is the inability to accept new ideas or suggestions or even answer the questions of the layman. There develops a "holier than thou" attitude which though unspoken says—"I have spent years of study on this subject about which you know nothing—if there is anthing new to be found out within the secret chambers of our professional fraternity—it will be tried and tested, and if it meets our rigid standards, it will be put into use—in the meantime keep your untrained nose out of it."

Another place where it shows itself is in preparing estimates of cost. If you want something done with strict economy, it's hard to get it. The answer is it can't be done. Most estimates are too cozy—too many allowances for contingencies. Human nature doesn't like to stick its neck out. Then when the propect goes ahead, everyone seems satisfied if the cost meets the cushioned estimate. Thus effctive pressure to keep costs down is often lost.

So it is with time requirements to complete work. Face is saved by allowing plenty of margin. If 10% more time is allowed than is really needed, the pressure for efficient management is lost. We would do a better job if we set goals 10% higher than possible attainment and failed by that kind of a margin.

On this same negativeness feeds that type of professional pride which resents the obtaining of opinions from other people—even people in the same profession. We see it every day. It is also what engenders that frequent and silly jealousy between professions.

People of real professional stature will look a fact in the eye even if it it bites them. With such open mindedness, they are the ones who frequently accomplish the so-called impossible.

FREDERIC C. WOOD

ALUMNI NEWS

THE 1952 FUERTES GRADUATE MEDAL

The faculty of the School of Civil Engineers is interested in receiving applications or suggestions for award of the 1952 Fuertes Graduation medal.

This gold medal is a tradition of many years standing, and is awarded annually by the faculty if a paper of sufficient merit, written by an alumnus of the Cornell School of Civil Engineering, is found.

Papers competing for the award can either be specially written or previously published, but in the latter case the paper must have been published since April 15, 1951. When the award was originally established by Dean E. A. Fuertes in 1893, he called for "A meritorious paper upon some engineering subject tending to advance the scientific or practical interests of the civil engineer," and this criterion still applies.

The author of a paper may submit a copy of his work in competition for the Fuertes medal or the suggestion as to an eligible paper of merit may be sent in by someone else.

The last award of the medal was made several years ago to Elwyn E. Seelye of the Class of 1904.

Any applications or suggestions should be forwarded to the Director, School of Civil Engineering, Cornell University, Ithaca, N. Y., before April 15, 1952.

Elwyn E. Seeley, C.E. '04, has published new second editions of the first two volumes of his well-known "Data Book for Civil Engineers." The books were issued in December by John Wiley & Sons.

A consulting engineer for nearly forty years, Mr. Seelye is the senior partner of Seelye, Stevenson, Value, and Knecht, a prominent New York consulting firm. The first volume of his comprehensive work covers "Design" while Volume II covers "Sepecifications and Costs." Volume III of the "Data Book," published in 1947, deals with field practice.

Clement R. Newkirk, B. Arch. '07, has been presented with the annual award for public service and civic improvement by the Central New York Chapter of the American Institute of Architects. The award, presented December 8, was given in recognition of his work on upstate college campuses. His firm designed Clara Dickson Hall.

T. Scott Miyakawa, M.E. '31, received a faculty fellowship from the Ford Foundation Fund for the Advancement in Education and is spending the year in Great Britain and on the Continent. "My main interests will be the social and human aspects of industrial relations and productivity, and certain phases of the artistic and cultural life of these nations. The tour is not intended for any monographic research, but for broadening my general background," he writes. His address is Boston University, 725 Commonwealth Avenue, Boston 15, Mass.

Henry Alfred Byroade, M.S. in Engineering '40, was recently appointed Assistant Secretary of State for Near Eastern, South Asian, and African Affairs. A West Point graduate holding the rank of colonel, Mr. Byroade is on leave to the state department. During the last war he built air bases in India and China, and in 1945-46 he was General Marshall's Assistant in the Chinese truce negotiations. He is now married and has three children.

Phillip H. Permar, B. Chem.E. '42, 319 Quackenbos Street NE, Washington 11, D.C., is now head of the metallurgical section of the Savannah River Plant of the DuPont Co. near Aiken, S.C.

Dean Hollister will be the guest speaker at a meeting of the Junior Branch of the Metropolitan Section of the ASCE on Wednesday evening, April 23. The meeting will be held in the ASCE Board Room at the Engineering Societies Building, 33 West 39 Street in New York, starting at 7:30 P.M. All interested Cornellians are invited to attend. The topic will be the engineering manpower shortage.

W. N. Kruse, B. Chem.E. '43, has been made co-ordinator between construction office in Chicago and construction jobs in the field for the Universal Oil Products Co., Chicago, Ill. Mr. Kruse is married, has an eight-months-old daughter, and a new house at 319 S. George St., Mt. Prospect, Ill.

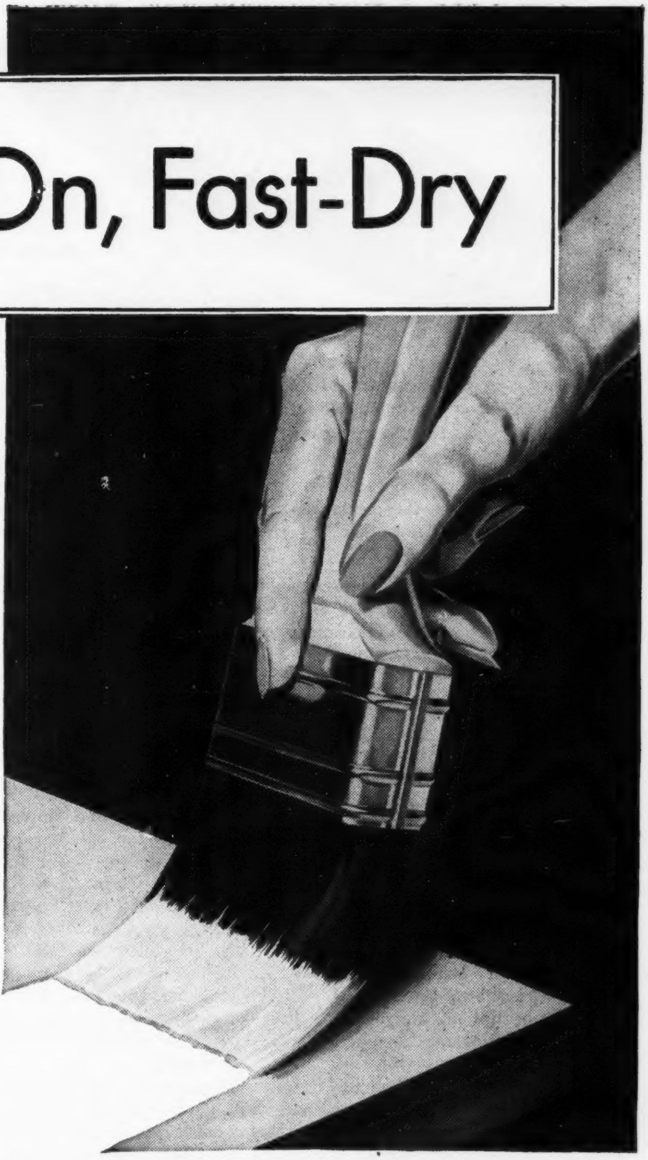
Clyde H. Loughridge, Jr., B.M.E. '43, graduated at Harverd Business School last June and is with Lincoln Electric Co in Cleveland, Ohio. He lives at 1248 Ramona Avenue, Lakewood 7, Ohio.

Harold Rueben, M.S. Chem.E. '45, is working as a development engineer for Republic Rubber Division, Lee Rubber and Tire Corp., Youngstown, Ohio. He is also teaching chemical engineering part time in Youngstown College.

H. G. Howe, B. Chem.E. '47, Bakelite Division Cyanamide Co., Bound Brook, N. J., is now working for his M.S. in Production Management at Stevens Institute. He has a daughter, Nancy, born January 14, 1951.

R. H. Schumacher, B. Chem.E. '48, is studying business administration at Hamilton Institute. Mr. Schumacher is the production supervisor in charge of soapmaking at the Ivorydale plant of Proctor and Gamble Co., Cincinnati, Ohio.

Easy-On, Fast-Dry



CHEMICAL PROBLEM...

. . . to help make enamels that combine fast drying and easy brushing—advantages not always found together in the two types of enamels most used today. One type of enamel brushes easier, the other dries faster.

SOLUTION . . .

. . . a new Hercules resin, Pentalyn® B-56. It reacts chemically with the other paint ingredients to favor neither drying speed nor brushing qualities unduly, but to provide the very best combination of both.

COLLEGE MEN...

This is but one example of the far-reaching chemical developments in which you could participate at Hercules—in research, production, sales, or staff operations. It suggests the ways Hercules' products serve an ever-broadening range of industries and end-uses.

Hercules' business is solving problems by chemistry for industry...

... paper, rubber, insecticides, adhesives, soaps, detergents, plastics, paint, varnish, lacquer, textiles, to name a few, use Hercules® synthetic resins, cellulose products, chemical cotton, terpene chemicals, rosin and rosin derivatives, chlorinated products, and other chemical processing materials. Hercules® explosives serve mining, quarrying, construction, seismograph projects everywhere.

HERCULES

HERCULES POWDER COMPANY Wilmington, Delaware
INCORPORATED
Sales Offices in Principal Cities

All-Weather Ventilation

(*Continued from page* 32)

the entire arena visible from every seat. This makes the problem of heating and ventilating more difficult because of the minimum space available for installation of heating equipment.

The unused area behind the balcony tiers proved to be an ideal location for heating machinery and doubles as the air plenum chamber. The exterior perimeter of the area is walled with 6-in. tiles, and an airtight seal is constructed between the bottom beam and the plaster ceiling of the concourse below.

The umbrella-like gypsum composition roof towers 98 feet above the center of the arena and is supported on steel trusses anchored to piers around the perimeter of the building. It was obvious to the designers that such a high roof would cause stratification of heat during the winter with resultant high fuel consumption. Conversely, during the summer, the high roof would hamper adequate ventilation under the Texas sun.

To solve this problem, return air ducts have been installed at stategic locations around the perimeter of the building at the top of the balcony tiers, nearly 34 ft. above the arena floor and 28½ ft. above the air discharge openings over the box seats. Air pulled into these 60 by 12 inch openings by the fans of the 16 Dravo heaters is carried back to the heaters for warming and recirculation to the arena. What has been achieved is, in effect, a controlled temperature "blanket" in that portion of the building where comfort is essential. The rest of the space high above the seating areas is unimportant from the heating and ventilating standpoint. The principle of air recirculation at the "use" level also tends to reduce roof heat losses during cold weather, thereby conserving fuel.

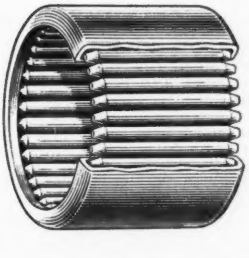
As a means of ventilating the area immediately underlying the roof, which is subject to summertime temperature buildup from solar heat, 30 propeller-type exhaust fans have been installed in a 12-ft. wide monitor with automatic shutters. Each fan has a diameter of 4½ feet, is powered by an individual 3/4-hp. motor and can handle 24,000 cu. ft. of air per minute. Operation of these fans helps in the overall ventilation of the building, especially important during livestock shows.

The coliseum building is 460 ft. long by 264 ft. wide. Outside walls are of brick and cast stone, with a large expanse of window area. Heat losses of the big structure were calculated at 10,800,000 Btu. per hour based upon the winter design temperature of 20°F. in San Antonio.

The 16 Dravo heaters are spaced equi-distant around the oval, suspended upside-down from steel angles attached to the 6-in. concrete floor slab above them. The area in which the heaters are located, immediately beneath the top tier of the balcony, is 10½ ft. high by about 12½ ft. wide. This area is above the 20-foot wide concourse of the Coliseum where exhibit booths

(*Continued on page* 52)

The Torrington Needle Bearing is designed for high radial loads



The many lineal inches of contact provided by the larger number of small diameter rollers give the Torrington Needle Bearing an unusually high load rating. In fact, a Needle Bearing has greater radial capacity in relation to its outside diameter than any other type of anti-friction bearing. This is illustrated in the table below, which compares the dimensions of three

	O. D.	I. D.	Axial Length
Torrington Needle Bearing No. B-1616	1¼"	1"	1"
Ball Bearing No. 405	3.15"	.98"	.83"
Bronze Bushing 3 sq. in area of bearing surface	1⅞"	1½"	2"

Dimensions for three types of bearings, all having the same rated radial load capacity.

bearings with identically rated radial load capacities.

Precision Manufacture and Unique Design

The exceptional load capacity of the Needle Bearing is the result of proper selection of steels, precision workmanship to close tolerances, and the application of modern anti-friction principles.

The one-piece shell, which serves as the outer raceway and retains the rollers, is accurately drawn from carefully selected strip steel. After forming, it is carburized and hardened. There is no further grinding or other operation that might destroy the wear-resistant raceway surfaces. The full complement of thru-hardened, precision-ground rollers is retained by the turned-in lips of the one-piece shell.

As the shaft is intended to serve as the inner race in most applications, it is hardened and ground to correct size. If an unhardened shaft is desirable, inner races can be furnished with the proper hardness.

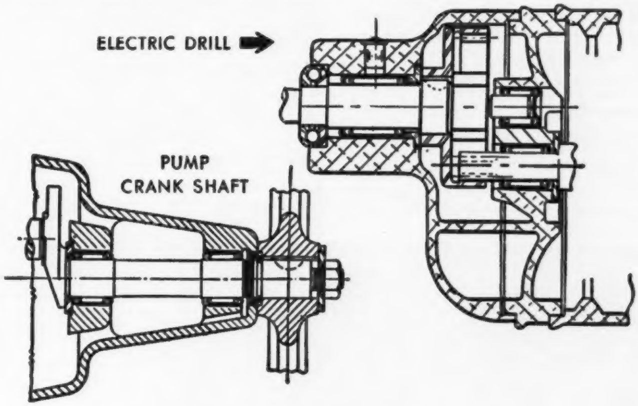
Plus Features For Modern Design

The unit design and compact size of the Torrington Needle Bearing provide other, related advantages which are being utilized in more and more applications.

The outer shell is easily seated by press fit into a straight bore housing, machined to the proper dimensions. No complex housing structures are needed – no spacers, retainers or snap rings required. And the compact size and light weight of the bearing itself also help make the end product lighter and less bulky.

Wherever high radial load capacity is vital, but space and weight are at a premium, Torrington Needle Bearings provide an ideal solution.

Future advertisements in this series will discuss other specific advantages of Needle Bearings. If you would like further information on these or any other type of anti-friction bearings, our engineering department will be glad to be of assistance.



High radial load capacity is vital in many bearing applications.

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON *NEEDLE* BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • BALL • NEEDLE ROLLERS

Science

(Continued from page 15)

the Twentieth Century and . . . the decisive instrument of the alteration will be progress in communications." Through this progress, distant parts of the world are, in effect, becoming nearer and nearer, and exchange of ideas is increasing. We are tending toward a "single global community." In this trend, atomic energy will play the key role, aircraft profiting the most. There are more limiting factors, he stated, to the development of land and sea-borne vehicles than to the development of aircraft. "In the air. . .the effects of atomic propulsion are certain to be revolutionary to an extent that staggers the imagination . . . The surfaces of the earth may be largely discarded as roadbeds of transportation. Everything will move through the air, including individuals, . . . (on vehicles) less complex than bicycles."

Space Flight

Throughout all five speeches, it was especially interesting to note the speakers' opinions on space travel. Dr. Harrison said that there would be no space travel within the next half century; Drs. Phillips and Price did not specifically commit themselves on this question; Dr. Hector said nothing about space travel and Major de Seversky said, "I am confident that interplanetary travel will be a reality before the end of the century." Major de Seversky went on to say that all we lack for this travel is fuel. Such flight will be measured by constant acceleration and deceleration instead of velocity, and there will be no discomfort, since the space ship will have artificial gravity.

A significant topic touched upon by all the speakers except Dr. Phillips was the possibility of a unified world by 2000. Dr. Harrison said that we would achieve such unification, the communist leaders and tenets defeating themselves. Drs. Hector, Price and Major de Seversky also believed this unification is coming; the first stressing the interdependence of the world; the second, that we would have a federal government through the United Nations; and the third, that the world will become simply one large neighborhood.

In closing the panel, Dr. Furnas made an important comment. He stated that scientists definitely are interested in world affairs. Major de Seversky had said earlier that scientists should accept philosophically that much of their work is directed first toward war, and that only slowly changing human nature could correct this. Dr. Furnas implied that scientists are and should be active in trying to make the world such that scientific achievements would be used for peaceful purposes. The panel speakers themselves were certainly quite interested in world affairs.

The general tone of the panel was optimistic, and was best expressed by the closing lines of Dr. Harrison. "[In 2000] citizens of the United States still eat too much, but the picture has changed in that now large numbers of Armenians and Chinese also eat too much."

When You Find the Work You Like

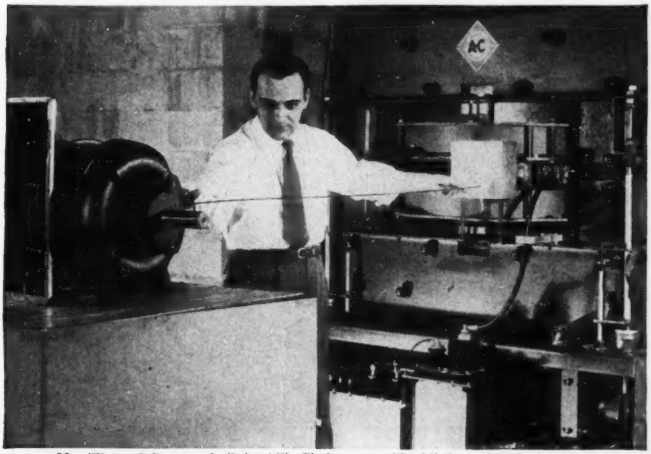
STAY WITH IT!

GORDON W. CLOTHIER

by GORDON W. CLOTHIER, *Manager, Transformer Section, Electrical Department*
ALLIS-CHALMERS MANUFACTURING COMPANY (*Graduate Training Course 1938*)

THAT'S a good plan, but there's just one little catch in it; sometimes it takes a good while to *find* the work that's right for you. If you're worried about that, perhaps my own experience will point out a practical shortcut.

I got my E. E. at the University of Washington in 1935, and went on with graduate work and teaching for another year. Then—into the practical business world. That's when I found the shortcut. I enrolled in the Allis-Chalmers Graduate Training Course in 1936, and very soon I got interested in the big transformers. I've been with them ever since, and they've given me a lot in accomplishment and satisfaction.



22-million-volt betatron built by Allis-Chalmers can "look" through 20 inches of steel to detect flaws. Here a technician is setting up motor specimen for radiography.

Back to Stay

Of course, during two years in the Graduate Training Course I got around a good deal in the big West Allis works. Had some time in the shops, got acquainted with the work of many departments, tried my hand at design, test, sales application work. But I came right back to transformers and have always been a lot more satisfied because I'd seen a broad range of other types of products and work at Allis-Chalmers.

In 1941 I became engineer in charge of transformer sales, and in 1947 was made manager of the transformer section.

This field offers both challenges and rewards. It needs and seeks men of superior intelligence, imagination and creative ability—men who will strike out into new paths of study and development.

If you think a transformer is an inert mass of iron and copper windings in a tank of oil—look closer. There are advanced problems in magnetostriction that if solved, will eliminate transformer hum and revolutionize the business. It's the same with problems in metallurgy, insulation, measurement and control of electric field shapes and the effects of time on materials. Perhaps some young engineer, even during his Graduate Training Course days here, may make important contributions. The opportunity is waiting.

What Do You Want to Do?

It's the same in other departments at Allis-Chalmers. Ore processing methods and machinery—electronic equipment—public works—steam turbine and generator design—hydraulics—manufacturing—research—sales—they all hold opportunities. Here you'll have a chance, as a Graduate Training Course engineer, to look over the widest range of industrial fields covered by any manufacturing firm in the country. You can help plan your own course, get advanced degrees. It's a shortcut to finding the work of your choice.

Write for information and literature, or call on the Allis-Chalmers district office in your locality.

Two-pass 45,000 sq. ft. surface condenser and two 42" x 30" vertical mixed flow pumps. Allis-Chalmers oval design saved space in this big new power plant.

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin

Graphite

(*Continued from page* 10)

ture lubricants. Today similar films applied by dipping, brushing, or spraying, provide trouble-free operation of baking and enameling oven chains, kiln car bearings, glass-making machines, incandescent lamp and vacuum tube equipment —to mention but a few instances typical of the many that require friction-reducing media more stable than mineral or compounded oils.

Effective Parting Compound

Graphite films deposited from colloidal suspensions are likewise important in the treatment of molds, "chillers," forging dies, and on pipe-threads, flanges, studs, and plugs.

Fig. 3. Sealing and sticking are minimized and finish greatly improved by pretreatment of forging dies.
—*International Harvester*

In the case of molds and dies, the castings or forged pieces do not stick and are characterized by their smoothness and cleanliness. The parting of threaded members assembled with colloidal graphite constitutes no problem, as is exemplified by the wide use of this treatment on the brass or cast-iron plugs used in heating and power boilers, exhaust manifold nuts on gasoline engines, bolts and nuts holding the bonnets of steam valves, and the flanges and studs on Diesel equipment. (See Figures 2 and 3.)

Electronic Applications

When a film formed with colloidal graphite is applied to the plates and grids of vacuum tubes,

(*Continued on page* 50)

"Where opportunity knocks every day"

This huge new building pictured above is one of the world's most modern petroleum research laboratories—those of the Standard Oil Development Company at Linden, N. J. It is the research center where Esso Products are constantly developed and improved by engineers and technicians whose aim is better products for better living all over the world.

Here chemists and engineers find limitless opportunities for the scientific advancement of petroleum research. Scientific exploration in all the phases of oil production is constantly encouraged at Esso.

The 28,000 workers at Esso have been with the company an average of over 14 years . . . 8,600 of them for 20 years or more. Esso is proud to have this large number of long service employees, enjoying fair pay, good working conditions, and a chance to learn more about the oil business and to advance in the company.

It has been an Esso Management policy for more than 30 years to keep *good people* happy at *good jobs* . . . and turn out consistently *good products* that carry the Esso trade-mark.

ESSO STANDARD OIL COMPANY

Graphite

(*Continued from page 48*)

these members operate at lower temperatures than untreated parts. This discourages undesired primary emission. Occasionally tube parts and envelopes are graphite-coated to prevent secondary emission.

The glass envelopes of cathode ray tubes for television receivers and oscillographs usually carry interior and exterior coatings of graphite. (See Figure 4.) They function as ray-focusing anodes, as opaquing media, as electrostatic shields, and to a lesser degree as gas adsorbers or "getters" In some cases the electron gun is sprayed to eliminate internal reflection.

Copper-oxide rectifier manufacturers use colloidal graphite for the formation of conducting films on the discs surfaced with the rather rough and crystalline cuprous oxide. Graphite exerts a leveling action, filling in the "valleys" between the crystals, and improves contact during assembly between the discs and plates of which these devices are composed.

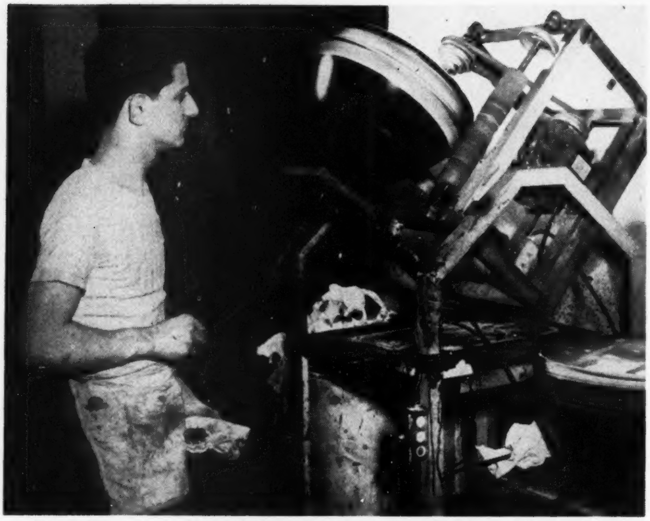


Fig. 4. The interiors of cathode ray tubes are coated with colloidal graphite.
—*Tel-O-Tube*

Films laid down from colloidal graphite suspensions are valuable as conducting lubricants in suspension-type insulators, on automatic electroplating equipment, and on heavy-duty switches.

Other electronic and/or electrical applications of colloidal graphite in one form or another involve the manufacture of fixed and variable resistors, light-sensitive cells, shielded electrical musical instruments, and the automatic tuning mechanisms of broadcast receivers.

Miscellaneous Uses

Because of the minute size of its particles, graphite in the colloidal state is used in numerous industries as an impregnating medium. Examples are: in brake linings to prevent momentary seizing or chattering; in packed materials as a lubricant; in and on driving belts to ground static charges; in fabrics to be used as soil standards for the evaluation of detergents; in porous bearings; and for rendering paper stock conductive.

In conclusion it would be well to add that the literature records a number of novel uses for colloidal graphite in the fields of biology and medicine, the most unusual of which is its application by Hacker as an impregnant for the breathing tubes of mosquito larvae.

Colloidal graphite is indeed a unique material, the usefulness of which continues to extend into fields far remote from its original function as a lubricant.

Titanium

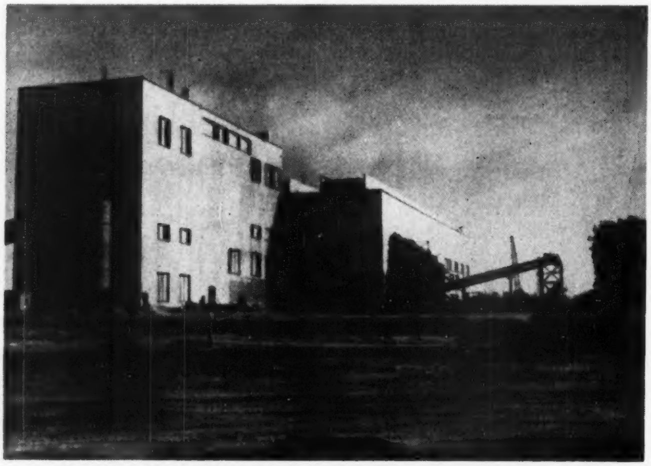
(*Continued from page 13*)

Properties of Titanium

As for titanium metal, the need is tremendous, but an economical process for its production is still needed. The present method involves converting the titanium oxide slag into titanium tetrachloride which is then combined with molten magnesium to give raw spongy titanium metal. The sponge must then be melted and poured into ingots before fabrication. One big disadvantage of titanium is its affinity for oxygen and other active gasses; even small amounts of these gasses will cause the metal to become brittle. As for its properties, titanium has a specific gravity of 4.5, half as light as steel (7.9) and about twice as heavy as aluminum (2.7). It melts at 1800°C, can be rolled, drawn, and is highly resistant to corrosion. The tensile strength of annealed titanium is 82,000 psi, and cold rolled to 50% reduction the tensile strength is about 126,000 psi, or 50% more than cast steel. Thus, with its lightness and tremendous strength, titanium has great potentialities in bridge and aircraft construction, and in transportation. The military is very much interested in titanium. Because of its resistance to salt (after 30 days exposure to salt sprays it showed no tarnish) the Navy is obviously interested in titanium for ship construction. As for the Air Force, titanium fits the strength and heat requirements of modern jet engines better than any other known material. Titanium metal in the form of ferro-titanium and ferro-carbon-titanium alloys have already found their way into the steel industry for use in improving the quality of steel.

Although welding is still in the experimental stage, spot welding, seam welding, and inert-gas shielded-arc welding do seem practical. The big problem is to prevent the contamination of the titanium by active gasses at the elevated temperatures required for welding. Soldering and brazing of titanium are still unsuitable for lack of a flux. Since it is both nontoxic and corrosion resistant, titanium also promises to have wide use in food handling equipment, surgical equipment, and various phases of medicine.

An unlimited market awaits the products from the Sorel plant. For titanium oxide there is already a proven market and for titanium metal (though still small)—an estimated 4500 tons in 1952—the market has gigantic possibilities. All that remains to open this new field is to find an economical means of production and a means of protection against active gasses. At present, with much of the metal industry working on these problems, their solution seems well within the realm of possibility.



The multi-million dollar smelter at Sorel. The Sorel plant is expected to produce over half the TiO_2 for U.S. consumption.

All-Weather Ventilation

(*Continued from page 44*)

and concession stands are situated.

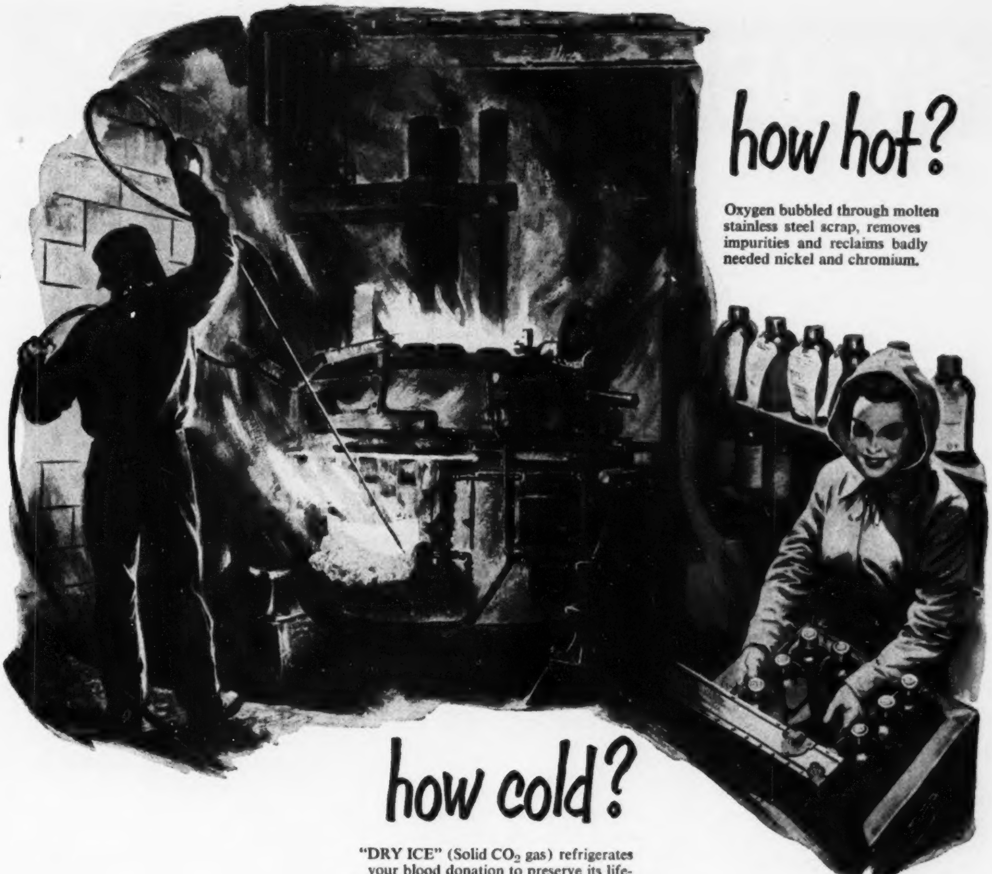
Each heater used in this installation has a capacity of 650,000 Btu. per hour and can handle, with its individual fans, a total of 7000 cu. ft. of air per minute at ½-in. static pressure. The heater fans, and the exhaust fan that provides inducted draft for the combustion chamber, are powered on a single shaft by a 3-hp. motor.

The entire air supply for each heater is drawn from the arena through the return air ducts. Some of the heaters have two return air ducts and others have three. Air from these ducts enters the base of each heater and is pulled downward by the fans. It passes first over banks of economizer tubes which carry exhaust gases to the 10-in. transit vent stack extending through the roof. The tubes serve to pre-warm the air and cool the exhaust gases. Cooling the exhaust in this manner has the advantage of extracting the most heat value from the fuel burned in the combustion chamber. After passing over the economizer tubes, the air then sweeps the heater's stainless steel combustion chamber in which the gas is being burned. Use of stainless steel for the combustion chamber gives the heaters longer service life and enables their installation in an inverted position because no refractory lining is required for the fire box.

The temperature of incoming air is raised approximately 80 degrees during the heating cycle. From the discharge outlet of each heater, the air empties into a supply duct. There is an opening in the top of this duct to allow part of the air to discharge into the plenum chamber behind the balcony, while the remainder is transported to the duct openings above the box seats.

The same air distribution pattern is effected for summer ventilating but the gas burners of the heaters are turned off.

Each fully-automatic heater is controlled by an individual thermostat in the plenum chamber. Maintenance in the plenum chamber is facilitated by a 3-ft. wide walkway installed along the back wall of the area.



STRESS *and* STRAIN...

A few days ago we came across a very unusual little story which we thought might interest the readers of the Engineer. *To be honest, we don't know who the author of the story is or where it was first printed. Nevertheless, we'll thank him for it and we think you will too.*

THE LOVE AFFAIR OF EDDY CURRENT

At time T equals zero there lived in a small cavity in a dielectric a poor struggling dipole by the name of Eddy Current. He was deeply in love with a beautiful double layer by the name of Anne Ion, the daughter of an influential force in the town, Gation. Anne was the center of attraction of the young dipoles of the town. Her golden coils, her symmetric line integrals, and her simple harmonic motion affected the susceptibilities of all the gay sparks. However, her father, a rich magnet and power factor, had laid down a strict set of boundary conditions for her future husband. Eddy's first contact with her came at a time T equals A. As he passed by a beauty parlor on his periodic orbit, he saw her having a standing wave induced in her filaments. She made a fine sight in her beautiful doublet and it was a case of mutual polarization.

By a coincidence they met at a dissipated function the following night. After a few oscillations to the strains of a number (N) by Mo Mentum and His Incandescent Tuning Forks, the couple diffused into the field outside. There on the Wheatstone bridge the young dipole felt that his big moment had come. "Gauss, Anne, you are acute angle! I am determined that U shall marry me for I sphere that I will never be happy without you."

"Oh Eddy, don't be obtuse," said Anne, "integrate out of here."

"Anne, are you trying to dampen my oscillations? Can't you see that I am in a state of hysteresis over you?"

"Now Eddy, be a discrete particle. What will father say?"

Eddy did not let her reluctance phase him, for he knew that it was only a surface charge. "I admit I only get paid a low calorie in my present position, but I have potentialities, and I am sure that money cannot BTU of any importance compared to my love."

Alas, there was also in this cavity a mean dipole who was resolved to marry this beauteous Anne, using coercive force if necessary. Hearing these murmurings of love he went Pi-ied with fury, and crept stealthily upon the couple with velocity V, his joules drooling with the bestial erg that moved him. "LS Schmidt," cried Anne, "What the infrared are you doing here, you flat-bottomed vial villain?" The situation grew tensor.

Schmidt advanced to choke the beautiful coil; Eddy offered resistance (R) and his capacity (C) for absorbing the charge (Q), but Schmidt lost little work content in knocking him out to infinity with a severe blow of his negative charge. Eddy made a quick comeback with acceleration A. Stripping off Schmidt's outer electrons, Eddy so upset the villain's equilibrium that he was converted into cosmic radiation and vanished in the realms of space, leaving Eddy the resultant vector of the combat.

Old Gation, attracted to the spot of Schmidt's oxidation, beamed upon the young dipole. "Brave young lad," he emitted, "you have satisfied the boundary conditions and by the uniqueness theorem you are the only one for my daughter."

"Our love will not be transient," said Eddy as he formed a closed circuit about her. "Darling, we will raise a one parameter family of second order infinitesimals," murmured Anne happily, as time T approached e . . . .

CHULIUS, DE DIESEL ENCHANEER

Leddle Chulius, haff no fear
You'll soon be a diesel enchaneer.
Onwerts, onwerts, we must go
'Cause ve luff doctor diesel so.
All important, neffer giff
A statement dot is positive.
Und if you must, be sure to throw
As much baloney as you know.
Ven dere's trouble mit injectors
Call a bunch of schmart inspectors.
Dey vill get into a huddle
Den dere'll be anudder muddle.
Ven she won't run like she oughter
Turn off all the cooling vater.
Den dose heads get red and blue
Chust from too much B.T.U.
Oh, alas! (und some alack)
Dot exhaust iss so damn black;
My, vot can the trouble be?
Maybe leaks out M.E.P.
Ven you feel a bad vibration
Send a broadcast over de nation
Calling for dose "viggle boys"
Mit dere fancy 'lectric toys.
They vill sneak up on dose viggles
Mitt some chuckles and some giggles.
Den, in two month you vill know
Vot makes diesels chiggie so.
Vatch dere chests svell up mit pride
Ven dere slip sticks schtart to slide
Und dere elbows swing in rhythm
Pushing out dose logarithithms.
Leedle Chulius, haff no fear
You'll soon be a diesel enchaneer
Und eventually you vill know
Vot makes diesel enchines go.

BRAIN TEASER

Shown below are nine dots arranged in a square. The object is to draw four straight lines so that each dot is intersected by at least one line; and the four lines are to be drawn continously; that is, without lifting your pencil from the paper.

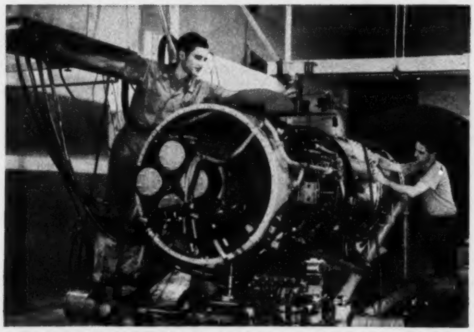
. . .

. . .

. . .

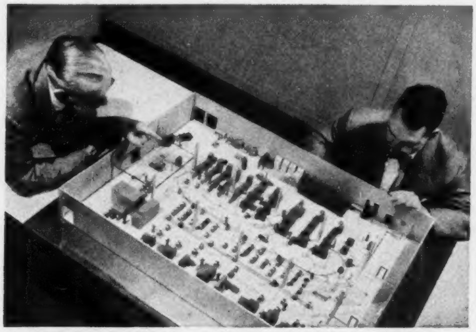
Answer to last month's brain teaser: 50 miles.

Five Ways to Begin Careers with General Electric

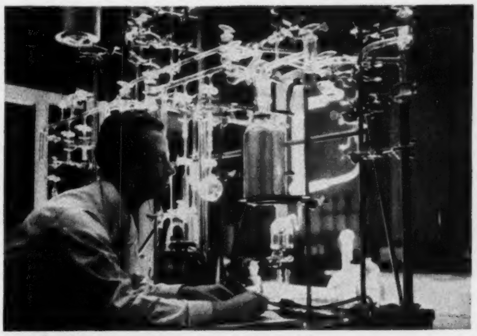


1. TEST ENGINEERS PROGRAM—gives engineering graduates opportunities for careers not only in engineering but in all phases of the company's business. Rotating assignments plus opportunities for further classroom study.

2. BUSINESS TRAINING COURSE—open to business administration, liberal arts and other graduates...for careers in accounting, finance, administration.



3. MANUFACTURING TRAINING PROGRAM—for developing manufacturing leaders. Open to graduates with a technical education or a general education with technical emphasis.



4. CHEMICAL AND METALLURGICAL PROGRAM—offers rotating assignments and studies for chemists and for chemical and metallurgical engineers.

5. PHYSICS PROGRAM—the gateway by which physics majors begin G-E careers. Program graduates have gone into such fields as research, development, manufacturing, design, marketing.

If you are interested in entering one of these five basic General Electric programs after graduation, talk with your placement officer and the G-E representative when he visits your campus. Meanwhile, send for further information:

- **On Test, Chemical and Metallurgical, and Physics Programs, write to Technical Personnel Services Dept., Schenectady, N. Y.**
- **On Business Training, write to Business Training Course, Schenectady, N. Y.**
- **On Manufacturing, write to Manufacturing Personnel Development Services Department, Schenectady, N. Y.**

GENERAL ELECTRIC